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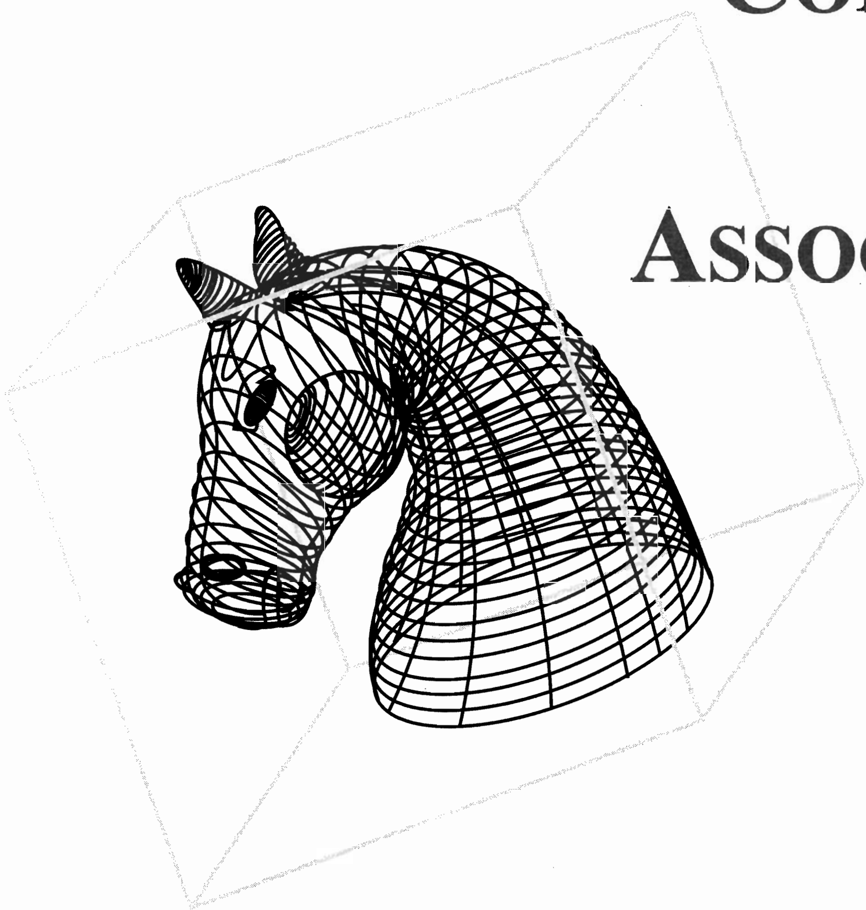

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Ken Thompson Special Issue

SOME INFORMATION ABOUT THE INTERNATIONAL COMPUTER CHESS ASSOCIATION (ICCA)

The ICCA was founded in 1977 and represents the Computer Chess World vis- -vis Computer Science Organizations, such as ACM and IFIP, and also vis- -vis the International Chess Federation (FIDE).

World-wide membership is over 500 and comprises individuals as well as university and industrial members.

The activities of the ICCA are:

(i) to publish a quarterly ICGA Journal;
(ii) to hold a triennial World Computer-Chess Championship;
(iii) to strengthen ties and promote cooperation among computer-games researchers;
(iv) to introduce computer games to the games world;
(v) to support national computer-games organizations and computer-games tournament organizers.

The ICCA takes pride in listing the roster of its Past Presidents:

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1983 - 1986	Monroe Newborn
1986 - 1992	David Levy
1992 - 1999	Tony Marsland

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ken

From the beginning, the world of game-playing by machine has been fortunate in attracting contributions from the leading names of computer science. Charles Babbage, Konrad Zuse, Claude Shannon, Alan Turing, John von Neumann, John McCarthy, Alan Newell, Herb Simon and Ken Thompson all come to mind, and each reader will wish to add to this list. Recently, the Journal has saluted both Claude Shannon and Herb Simon.

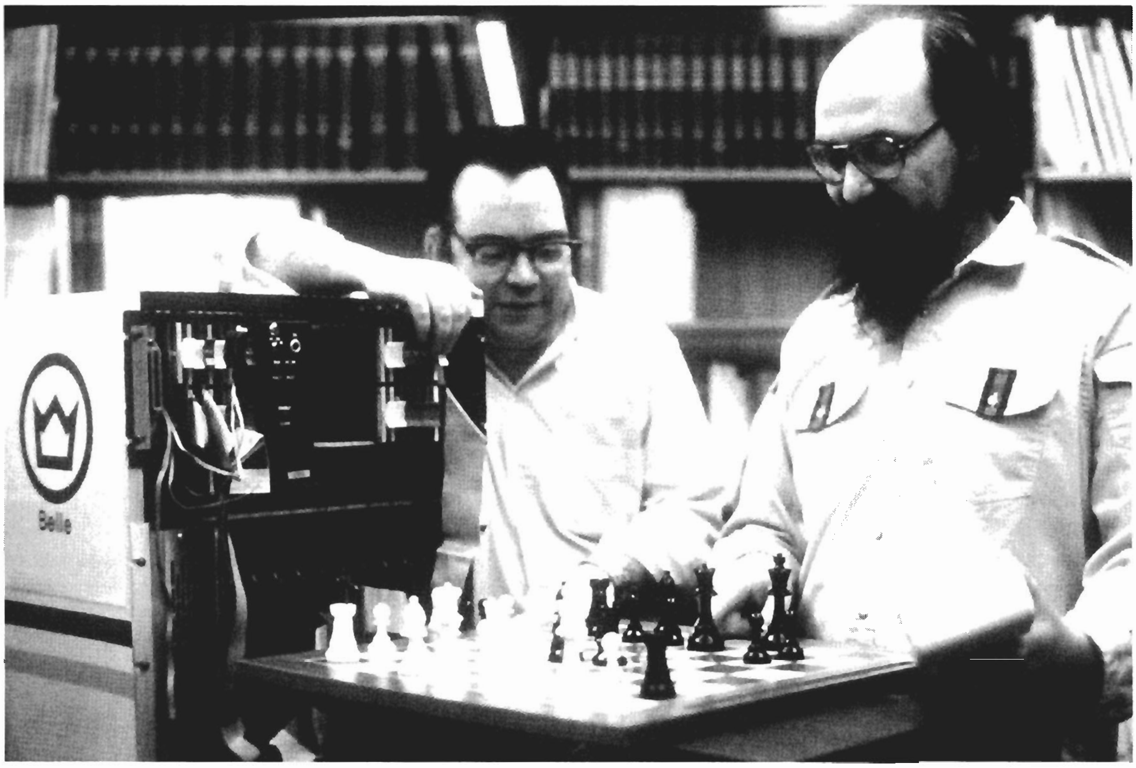
Ken's retirement from Lucent Technologies' Bell Labs to the start-up Entrisphere is also a good moment for reflection. He is principally known as the father of UNIX and has been the recipient of some six prestigious awards including two IEEE awards, the ACM Turing Award and the National Medal of Technology of the USA. He was also awarded the first Fredkin prize in 1983 when BELLE, ACM and World CC Champion, won the title of U.S. Chess Master. The endgame CDs earned an ICCA Award, and here, the ICCA thanks Ken for his significant and enduring contributions to our community by revisiting some of the themes he developed.

UNIX and C developed in symbiosis and Dennis Ritchie, father of C, leads off by giving us his view from the next desk at Bell. He recreates the special culture of the research community there, simultaneously both liberal and productive, illustrating the sometimes surprising connections between Ken's games-related and other work. Jonathan Schaeffer reviews Ken's three principal contributions to computer game-playing, and Jaap Van den Herik mentions other activities and achievements: ICCA administration, event participation and success, opening-book preparation, intelligent computer vision and player-rating systems.

Ernst Heinz surveys the research inspired by and/or closely related to Ken's pioneering self-play experiments. He announces the results of his own most comprehensive investigation. It appears that statements about the decreasing returns of increasing search may soon be made with high levels of statistical confidence.

Ken's computer chess interest began early - he wrote a chess-playing program mentioned in UNIX's first edition manual (1971). This earliest effort was purely in software, but fairly soon he began to build hardware to help out: the various hardware-assisted BELLE programs (Condon and Thompson, 1983) were the result. The earliest hardware was almost purely a move-generator.

Later versions began to incorporate increasingly sophisticated board evaluation and parts of the tree searching algorithm in the programmed logic. Still later, he began his long-term endgame database project.



BELLE, Joe Condon and Ken Thompson revisiting the 1978 ACM BLITZ 6.5-BELLE game[2] (1982).

Ken was and is amazingly productive, and became involved in many things. Often the diversions sparked by games created economically productive research. If the most obvious was the take-over of the PDP-7, others are less visible; the same semi-automated wire-wrap machine that Ken and Joe Condon assembled was used to construct not only BELLE, but also much other research hardware used in Bell Labs, for example for the calculation of Ising models in the physics of spin glasses.

In more recent years, Ken spent much time on the software-engineering aspects of clever compression and decompression of digital music, based on algorithms and research done by a nearby group in AT&T and now Lucent. In the course of this visibly company-related work, he also collected an enormous quantity of digitally-encoded music, mostly for his own enjoyment. No, none of it came from or was made available to Napster.

When the chess aspect of Ken's career became visible, and in particular when BELLE began doing well in computer chess tournaments, our management must have worried a bit about whether we wanted publicity about developing a champion chess-playing machine. So far as I know, these worries were not expressed to Ken, even in the face of a hilarious fake memo, written on the real, albeit stolen, letterhead of AT&T's chairman.

---

[2] ACM CCC, Washington D.C., Round 4, Dec. 5th, 1978: ECO C48, Four Knights. 1. e4 e5 2. Nf3 Nc6 3. Nc3 Nf6 4. Bb5 Nd4 5. Bc4 Bc5 6. N×e5 Qe7 7. B×f7+ Kf8 8. Ng6+ h×g6 9. Bc4 N×e4 10. O-O R×h2!! {c.f. the photo} 11. K×h2 {hastening the loss} Q×h4+ 12. Kg1 Ng3 13. Qh5 {ineffectual delay} g×h5 14. f×g3+ Nf3# {perhaps uniquely blocking a check, giving a double check and mating simultaneously; "the most beautiful combination created by a computer program to date ... computer chess witnessed the start of a new era." (Levy and Newborn, 1991)}.

AT&T

John D. deButts
Chairman of the Board

American Telephone and Telegraph Company
195 Broadway
New York, N.Y. 10007
Phone (212) 393-1000

December 6, 1978

12/7
Mr. Samuel P. Morgan, Director
Computing Science Research Center
Bell Laboratories
600 Mountain Avenue
Murray Hill, New Jersey 07974

Dear Mr. Morgan:

A question has been raised by the intervenors Paul, Weiss & Co. (representing Mrs. Wilma Soss) in the California Public Service Commission rate filing CA-78-353.18, section C(iv)(2), with respect to the "T. Belle Computer" project in progress in your area. They request a detailed breakdown of expenditures and an allocation to inter- and intra-state services respectively.

The time period covered by this accounting should include case items from January 1, 1976 and plant items from January 1, 1974. If there have been any military uses of this work in connection with remaining Ocean Systems contracts, please itemize separately with appropriate cost distributions.

The intervenors also wish to know why equipment was not purchased in the nonregulated market rather than built within the Bell System. For antitrust purposes, please forward your evaluation of outside hardware and software indicating suitability for operating telephone company use.

Finally, the intervenors claim that although a two person game may reasonably be considered communications a game with less than two human participants is not communications, but rather data processing, and therefore forbidden business under section IV(a) of the 1956 Consent Decree. You are asked to suspend all use of this program that does not involve at least two human opponents, until such time as final legal opinion is received on this issue.

A response to the Public Service Commission is required by December 31, 1978.

Sincerely,

Copy to
C. L. Brown

The fake memo[3].

---

[3] Some background: In 1978, AT&T was rather closely regulated both by the federal government and in each state by their regulatory commissions. In particular there were rules about being a communications company and not a computer (or for that matter a fast-burger) company, the fear being that regulated business with fixed rates would subsidise entrepreneurial things. The California regulatory group was one of the particularly difficult ones. Wilma Soss was a perennial gadfly at shareholder meetings including AT&T's, asking peculiar and embarrassing questions out loud.

The 'memo' was created by Mike Lesk (of uucp, lex and other things) on the board chairman's, deButts', actual stationery. Sam Morgan, CSRC Director at the time, was half-way through the memo before he suspected a fake.

Ken and Dennis receiving the National Medal of Technology from President Clinton (1999).

IBM, I have learned, went through the same managerial soul-searching over the DEEP BLUE research project that culminated in the famous Kasparov matches. Both AT&T and IBM seem to have ended up winners, both in publicity and technology, by backing their researchers' unconventional tendencies.

Ken has always been a problem solver and a tool builder. He is equally excited by games, puzzles, and technology creation, and I don't think he really distinguishes among them.

Acknowledgments: BELLE photo courtesy of Bell Labs, Lucent Technologies and with thanks to Patrick Regan who discovered it. Michael Lesk's fake memo was preserved by Brian Kernighan and provided recent amusement for Lesk and Sam Morgan. White House photo courtesy of the U.S.A. Government.

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KEN THOMPSON'S INFLUENCE ON COMPUTER GAMES RESEARCH

J. Schaeffer[1]

Alberta, Canada

Most computer people would be hard pressed to name the inventor of the UNIX operating system. Of those who know of Ken Thompson's pivotal role in computer science history, few could name any of his other major scientific accomplishments. Having one major scientific triumph in a career is something that most people would envy. However, UNIX is just the best-known of Ken's long list of achievements. Brian Kernighan, a long-time colleague of Ken, once told me that Ken was at the heart of many of the important computing-related contributions that came out of Bell Labs (and now Lucent Technologies) over the past three decades.

So, why isn't the name Ken Thompson better known? In my opinion, it is because of his reluctance to write. Ken let other people write papers; he preferred to write code. Hence, his publication record is relatively small. However, the list of acknowledgments he received in papers authored by other people would be substantially longer. That was just the way Ken operated. He eschewed the limelight, preferring to work on what interested him, offering valuable advice to whoever needed it.

Today, it is easy to overlook the major contributions of Ken Thompson to the game-playing community. We all take for granted that faster machines result in deeper searches and (therefore) stronger game-playing programs. When we think of a high-performance special-purpose game-playing machine, DEEP BLUE comes to mind. Endgame databases are a way of life for many games, including chess, checkers, and awari. However, a quick literature search will show that Ken Thompson was in large part responsible for all three of these major insights into computer games. For almost 20 years, these three results have driven many of the research directions in computer chess (and computer games), culminating in the 1997 DEEP BLUE victory over Garry Kasparov.

- **Equating Speed with Playing Strength**

Ken's innocuous paper (Thompson, 1982) on computer self-play games (a mere two pages in length) had a profound impact on the mentality of the game-programming community. He showed that a single ply of search was worth roughly 200 rating points, an impressive number of points for a relatively modest improvement in performance (roughly a factor of five, something easily achieved at least every four years due to Moore's Law). This paper gave a recipe for success: all one had to do was build a faster chess search engine. The race was now on for better algorithms, more efficient implementations, parallel searching, and, of course, special-purpose hardware. More importantly, Ken's paper tantalized us: by equating performance with speed, one could extrapolate the results to approximate when a chess machine would be comparable in strength to the human world chess champion. Ken's experiments have been repeated many times for chess and other game-playing domains, e.g., by Hyatt and Newborn (1997) and Heinz (2000).

- **Special-Purpose Hardware**

Ken Thompson and Joe Condon shook the computer chess world and the artificial intelligence community with their chess machine BELLE (Condon and Thompson, 1982). Richard Greenblatt was the first to propose a chess machine (Greenblatt, Eastlake and Crocker, 1967) but he was never able to demonstrate it successfully. In many ways, much of DEEP BLUE's success can be attributed to BELLE chess hardware. In particular, Ken's design of the hardware move generator was a key component of the DEEP BLUE design (Hsu, 1999). Feng-Hsiung Hsu subsequently modified it to fit into a single chip, as well as several other enhancements, but the core design remained essentially the same (Hsu, 2002). The result was a chip capable of analysing over 2,000,000 chess positions per second (using 1997 technology!), and a victory over Garry Kasparov.

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- **Endgame Databases**

  Although Ken was not the first to publish the idea of retrograde analysis (Ströhlein, 1970), he was the first to recognize its power (Thompson, 1986). Even the simple chess endgame of KQ versus KR proved an effective demonstration to chess grandmasters. Ken has computed chess endgame databases on-and-off for over 20 years, resulting in new insights into the secrets of endgame play, overturning many human pre-conceived ideas (e.g., showing that KBB versus KN is generally not a draw (Thompson, 1986)) and resulting in changes to the 50-move rule in chess.

  Endgame databases were a major factor in the checkers program CHINOOK, the first program to win a human world championship (Schaeffer, 1997). Endgame databases were critical in solving Nine Men's Morris (Gasser, 1995) and will soon result in solving the African game of awari (Lincke and Marzetta, 2000, Van der Goot, 2001).

A subtle contribution by Ken, but one that was very important to our community, was his name and reputation. Ken actively participated in many computer-game events - tournaments and conferences - and his name added luster, prestige, and status to our community's efforts.

The computer-games community is deeply indebted to Ken. His scientific contributions have had a profound impact on the community, and continue to influence games-related research to this day. Few scientific publications in the fast-moving field of computing science have a life-span of more than a decade. Ken has several enduring papers, some little known outside the realm of computer-games programmers. But to our small community, these works stand the test of time and establish Ken Thompson as one of the pioneers in our field.

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THE BELL CAPTAIN

H.J. van den Herik[1]

Maastricht, The Netherlands

Here, in complementing other retrospectives in this issue of the *ICGA Journal*, we highlight further the multifaceted nature of Ken's contribution to the computer games community, and the 'Man and Technology' theme which has characterised his approach to life.

ICCA Secretary/Treasurer

In 1977, the ICCA was founded during the Second World Computer-Chess Championship in Toronto. The organisation was the brainchild of Barend Swets and many participants supported the idea, among them Ken Thompson who then tied for 4th place amongst 16 participants with his program BELLE. CHESS 4.6 won the title but Ken received credit for BELLE's KQKR endgame play against IGM Walter Browne (Fenner, 1979). Further, Ken agreed to serve as Secretary and Treasurer of the new organisation alongside Ben Mittman, the first ICCA President, and did so successfully and with much enthusiasm for six years.

His motive was to build a strong organisation so that computer chess could flourish and, at that time, he did everything he could to support this aim. Being a chess player of some capability himself, he was thrilled by the idea that a machine might play chess at a level that would be recognised by the chess world. To this end, and since acceptance is usually earned by actual results, he went with the continually improving BELLE from one weekend tournament to the next. Then he had the idea of moving much of its functionality to hardware (Condon and Thompson, 1982).

World Champion

In 1980, BELLE was the odds-on favourite of the 3rd World Computer-Chess Championship. However, it was not a walk-over: the 2nd-round game against NUCHESS ended in a draw and a play-off against CHAOS was needed before BELLE secured the title. Although so much was at stake, Ken was not at all nervous: together with Joe Condon, he had carefully prepared for the tournament and was convinced that they had done their utmost. Their attitude was that it should be sufficient or they would do better next time.

Opening Book Compiler

For Ken, building a chess machine was just one aspect of a large computer-chess project. Many other considerations had to be taken into account. For instance, chess players should be helped. Long before CHESSBASE and NICBASE started their activities, Ken had begun to collect Grandmaster, Master and computer games. First, the collection was meant only for retrieval but later Ken incorporated it in BELLE itself to provide it with an outstanding opening book. As a result many questions arose, for instance, "Is 1. … a6 a good move after 1. e4"? It scored 100 percent (1 out of 1), the sole example being the famous game Karpov-Miles played in Skara, 1980 (Matanović et al., 1980). According to Ken, a move should feature in at least ten games before being considered seriously.

Chess Reader

Despite many great stories of halls of typing secretaries supporting US computer specialists to perform their tasks, Ken himself had to enter all the chosen games in BELLE's book. Of course, this was a thankless chore so Ken developed a program that could read the chess moves in all the relevant languages — English, Spanish, French, German, Dutch and so on. Since humans are fallible, the game scores were correctly assumed to be full of mistakes. Therefore, next to the optical-character-recognition program, Ken developed a program that analyzed the moves for consistency and made as many corrections as possible. It is one of his less-known achievements but fortunately, he later co-authored a commendable paper on this topic (Baird and Thompson, 1990). Other communities, wishing to capture their heritage electronically, could well emulate this feat of domain-intelligent character recognition.

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Bell Captain
In 1982 Ken supported the participation of our program PION (Delft University of Technology) in the 12th ACM Championship in Dallas, Texas. He received the program by email, fixed some bugs, restructured the program and gave some advice. Our question on his opinion was answered by "it plays". In the hotel hall of the tournament site, there was one impressive place – obviously meant as the seat of the Chairman of the hotel's Board of Directors. Indeed, it was reserved for 'The Bell Captain' and Ken was duly photographed as such, standing behind the bell, by Tom Fürstenberg. Unfortunately, the picture has disappeared but 19 years later, the memories remain.

Inspiration and Author
In my role as Editor-in-Chief, I have had many talks with Ken, for instance on the publication of his results. He never cared to publish them but was always prepared to provide them for publication, especially in the *ICCA Journal*. So, it happened that the Editors (Herschberg and van den Herik) often phoned Ken at Bell Labs to receive the latest information to be included in the next issue of the Journal. Time and again he refused to be credited as an author and stated, "Do with it what you think is possible." In the circumstance, the best we could was to put his name in the title (cf. Herschberg and van den Herik, 1986; van den Herik and Herschberg, 1987; The Editors 1992, 1993); Tamplin and Haworth (2001) continue the tradition. We were therefore delighted when Ken eventually authored his own contributions to the Journal (Thompson, 1986, 1996).

Player Grader
Another of Ken's achievements was the development of an improved rating system. It was more sophisticated than but never replaced the Elo system (Elo, 1978). However, it re-addressed the principles of grading (q.v. Beasley, 1989; Glickman, 1995) and was adopted by the PCA, the Professional Chessplayer's Association.

Combining science, literature and art, I would say "Ken has initiated more scientifically than James Joyce would be able to report in his stream of consciousness. He is a hero of modern times of which Chaplin must have dreamed. Thank you, Ken, for your many and varied contributions."

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SELF-PLAY, DEEP SEARCH AND DIMINISHING RETURNS

Ernst A. Heinz[1]

Cambridge, USA

ABSTRACT

Over the years, the research inspired by and/or closely related to Ken Thompson's pioneering self-play experiments with his chess machine BELLE in the early 1980s provided many valuable insights and controversial topics for discussion in computer game-playing. This brief survey of the field demonstrates the fertility of Thompson's original work. The overview includes a quick summary of the author's own latest self-play experiment, also seeded by Thompson 20 years ago.

"The fundamental principle of science, the definition almost, is this: the sole test of the validity of any idea is experiment."— R.P. Feynman

1. INTRODUCTION

Since the early days of computer strategy game-playing, researchers in the field have been captivated by the question of performance scalability. How exactly does the playing strength fare with more and ever increasing computational power? Conventional wisdom based on past experience predicted that the resulting performance graph ought to resemble a typical saturation curve with strong early gains and *diminishing returns* later on.

Because of its role as the initial *Drosophila* of Artificial Intelligence, computer chess received much attention regarding its performance scalability. To the best of our knowledge, Gillogly and Newborn independently reported the earliest attempts at modeling the relationship between the playing strength of chess programs on one hand and the available computing power on the other. Gillogly (1978) introduced his *technology curve* that plots the playing strength against what he calls "machine power" on a logarithmic scale. Newborn (1978, 1979) relates the numbers of nodes searched by different chess programs in three minutes (the average time per move in tournament games) to the playing strengths of the programs as derived from their performances in tournaments. Later on, Levy (1986) and Levy and Newborn (1991) refined Newborn's initial scheme by contrasting the highest rated tournament performances of the best chess programs with the time when achieved.

Interestingly enough, none of these studies revealed any diminishing returns as initially expected. Instead, the data and graphs showed only linear scaling of the playing strengths for all programs and time periods covered. This inevitably led to speculative extrapolations which Levy (1997) characterized as the "meta-science of prediction in computer chess" in his latest article about the subject. Among others, IBM's DEEP BLUE team based their performance predictions on linearly scaled extrapolations (Tan, 1995).

2. HANDICAP SELF-PLAY

While studying the performance scalability of his chess machine BELLE, the then reigning World Computer-Chess Champion, Thompson (1982; Condon and Thompson, 1983) introduced *handicap self-play* to the field. Self-play with handicaps in search depth, search speed, or search time between otherwise identical program versions represents a more rigorous approach to investigate the relationship of computing power and the strength of game-playing programs. A notable advantage of such matches is that the scoring rates quantify the differences in playing strength of the various participating versions of the same program. Despite unresolved

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Year	Program	Experimenter	Depths (in Plies)	Δ ELO (per Ply)	No. of Games All	No. of Games Each
1982	BELLE	Thompson	3 – 8	+246	100	20
1983	BELLE	Condon, Thompson	4 – 9	+217	300	20
1988	TECHMATE	Szabo, Szabo	– –	– –	6,882	≥ 32
1990	HITECH LOTECH	Berliner et al.	4 – 9	+195 +232	1,056	16
1994	ZUGZWANG	Mysliwietz	– –	– –	450	50
1996	PHOENIX	Schaeffer	4 – 9	+228	120	20
1997	THE TURK	Junghanns et al.	3 – 9	+200	480	80
2000	FRITZ 6	Heinz	5 – 12	+169 ↘ +84	21,000	3,000

Table 1: Timeline of published self-play experiments in computer chess.
[TECHMATE and ZUGZWANG self-played with time handicaps.]

questions regarding the magnitude of self-play rating differences (Berliner et al., 1990), self-play seems to be among the best of the available methods to resolve the old but still ongoing *search versus knowledge* debate (Schaeffer, 1986; Schaeffer et al., 1993; Junghanns and Schaeffer, 1997). Nearly everybody seems to agree with the intuitive notion that the positive effect of more search ought to taper off with increasing overall search effort. Yet, it is not obvious when and how such "diminishing returns for additional search" start to kick in.

In self-play matches, diminishing returns should lead to lower scoring rates of the deeper or longer searching program versions with the progression towards higher depths. However, Thompson's famous experiments (1982; Condon and Thompson, 1983) led to the surprising result that the playing strength of BELLE increased almost linearly with search depth. For searches with fixed iteration depths of 3 to 9 plies, the increase in playing strength amounted to roughly 200 ELO rating points per ply. This corresponded quite nicely with Newborn's (1978) earlier hypothesis of gaining 100 ELO rating points when doubling the speed of a brute-force chess program. Several other researchers later confirmed Thompson's findings by self-play experiments with their own chess programs HITECH, LOTECH, PHOENIX, and THE TURK (Berliner et al., 1990; Junghanns et al., 1997). In Figure 1 of their text, Junghanns et al. (1997) show that the scoring rates of the program versions searching one ply deeper remained range-bound between 70 to 80 percent in all cases. There are no clearly visible average downward trends at the end of these 9-ply data curves.

Table 1 presents an overview and timeline of self-play experiments in computer chess published up to now. Beside names, depths, and average ELO increases, the table also lists the overall numbers of games played as a whole and for each single match. Unfortunately, the aforementioned experiments (up to 1997 in Table 1) do not feature enough games per match to quantify the rating differences between the opponents with high statistical confidence (Heinz, 2000a, 2001b). Hence, Mysliwietz' (1994) comments on the statistical uncertainty of well-known self-play results in computer chess were justified.

3. "GOING DEEP" AND OTHER RELATED WORK

Newborn (1985) proposed another clever scheme to model the performance scalability of chess programs. The rationale of his novel approach sprang from the assumption that new best moves discovered at higher search depths ought to represent better choices than the best moves preferred at shallower depths. To this end, Newborn tracked the behaviour of Thompson's chess machine BELLE for searches to fixed iteration depths of 11 plies on a set of 447 positions from real games. Interestingly enough, his data correlated closely with the earlier self-play results of BELLE (Thompson, 1982; Condon and Thompson, 1983).

However, Newborn's "go deep" approach did not gain much popularity with other researchers until more than 10 years later. Junghanns et al. (1997) let PHOENIX and THE TURK search roughly 1,000 positions from self-play games to fixed iteration depths of 9 plies while recording new best moves beside other information. During the same year, Hyatt and Newborn (1997) conducted another behavioural experiment with Hyatt's chess program CRAFTY searching 347 new positions to iteration depths of 14 plies. This experiment revealed the astonishing fact that the rate of new best moves chosen by CRAFTY at high depths of 9 to 14 plies remained

Depth	m	W : D : L / Total	Wins	Draws	Losses	Score	Δ ELO
6 ⇔ 5	63	1,686 : 915 : 399 / 3,000	56.20%	30.50%	13.30%	71.45%	+159
7 ⇔ 6	65	1,643 : 1,066 : 291 / 3,000	54.77%	35.53%	9.70%	72.53%	+169
8 ⇔ 7	67	1,457 : 1,212 : 331 / 3,000	48.57%	40.40%	11.03%	68.77%	+137
9 ⇔ 8	66	1,433 : 1,235 : 332 / 3,000	47.77%	41.17%	11.07%	68.35%	+134
10 ⇔ 9	68	1,252 : 1,451 : 297 / 3,000	41.73%	48.37%	9.90%	65.92%	+115
11 ⇔ 10	67	1,124 : 1,525 : 351 / 3,000	37.47%	50.83%	11.70%	62.88%	+92
12 ⇔ 11	68	1,059 : 1,592 : 349 / 3,000	35.30%	53.07%	11.63%	61.83%	+84

Table 2: Match details of FRITZ 6 self-play results; m = avg. no. of moves per game (Heinz, 2001a).

quite steady around 15 to 17 percent on average and hardly decreased anymore. Following up thereon, we confirmed Hyatt and Newborn's findings by repeating their "go deep" experiment with our own chess program DARKTHOUGHT (Heinz, 1998, 2000a). After that we pushed the limit of "going deep" to an iteration depth of 16 plies (Heinz, 2000a, 2001c) where the best-change rate of DARKTHOUGHT still remained steady at roughly 15 percent.

Self-play with handicaps in search depth, search speed, or search time between otherwise identical program versions is extremely valuable as a tool not only for computer chess but for computer game-playing in general. Good examples from other domains than chess include self-play experiments in computer checkers (Schaeffer et al., 1993; Schaeffer, 1997; Junghanns and Schaeffer, 1997; Junghanns et al., 1997) and computer Othello (Lee and Mahajan, 1990; Brockington, 1997; Junghanns and Schaeffer, 1997; Junghanns et al., 1997).

4. DIMINISHING RETURNS IN SELF-PLAY

Based on Mysliwietz' (1994) comments, we carefully re-analyzed the self-play experiments up to 1997 listed in Table 1 (Heinz, 2000a, 2001b). The outcome of our analyses showed that none of them provide statistically confident quantifications of the differences in playing strength, not even at a relatively low statistical confidence level of 90 percent. The experiments did not run enough games per match to draw more reliable conclusions. Based on rigorous analyses of hypothetical match results, we conjectured that at least 1,000 games per match are necessary to assess diminishing returns in computer self-play with 95 percent statistical confidence. Further questions arise regarding the exact meaning of "fixed depth" in each case, the details of the experimental setups, and their repeatability.

Therefore, we conducted our own new self-play experiment (Heinz, 2000b, 2001a) designed in such a way as to overcome the drawbacks of its predecessors. Our primary concerns were the rigorous analysis of the results and their statistical significance. We played seven "depth X+1 ⇔ X" handicap matches at fixed iteration depths ranging from 5 to 12 plies with 3,000 games per match (see "FRITZ 6" in Table 1). By extending the self-play depths beyond 9 plies for the first time ever, we hope to have pushed the limits of performance scalability for computer chess substantially. Moreover, we wanted our self-play experiment to be transparent and realistic at the time of execution and independently repeatable by others later on. To this end, we chose a state-of-the-art contestant featuring general worldwide availability, x86-PC compatibility, well-defined parameter control, and – last but not least – handicap self-play ability: FRITZ 6 (written by Frans Morsch and Matthias Feist). Further advantages of employing FRITZ 6 sprang from its database capabilities, versatile chess-engine concept, and excellent opening book (compiled by Alexander Kure). In particular, the wide and well-balanced opening book facilitates the automatic play of fair matches with thousands of games. For a more extensive discussion of the whole experiment and its setup, please see the original texts referred to above.

The overall conclusion of our experiment is that it not only hints at but clearly shows the existence of diminishing returns for additional search in self-play by the chess program FRITZ 6. The scoring rates of the deeper searching program versions steadily decline from 72.5 percent for "7 ⇔ 6" to a mere 61.8 percent for "12 ⇔ 11" (see Table 2). The average rating increase for an additional ply of search (measured in iteration depth) shrinks by half from 169 ELO for "7 ⇔ 6" to just 84 ELO for "12 ⇔ 11". The diminishing effects kick in strongest with FRITZ 6 at iteration depths beyond 9 plies. These depths lie just outside the range covered by previous self-play experiments (see Table 1). Ignoring the matches beyond "9 ⇔ 8", our results actually re-

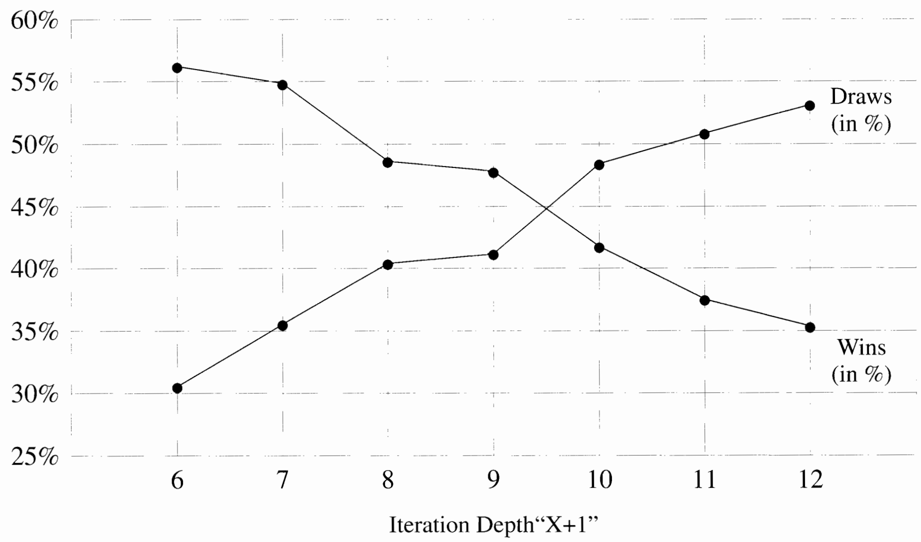

Figure 1: Self-play win / draw rates of FRITZ 6 from depths "6 ⇔ 5" to "12 ⇔ 11".

semble the past scores obtained by other researchers. As in those cases, our data does not confirm the existence of diminishing returns for the depth range of 5 to 9 plies alone with 95% statistical confidence. Based on the large number of 3,000 games per match in our experiment, we may therefore conclude with good confidence that diminishing returns remain subdued for FRITZ 6 in self-play at low iteration depths.

However, further evidence for the existence of diminishing returns is visible from the "W : D : L" data. The changes in the rates of games won and drawn by the deeper searching program versions are of particular significance in this context. While the rates of lost games stay fairly constant around 11 percent, the rates of won games decrease steadily from 56.2 percent for "6 ⇔ 5" to 35.3 percent for "12 ⇔ 11". Conversely, the rates of drawn games increase from 30.5 percent for "6 ⇔ 5" to 53.0 percent for "12 ⇔ 11" (see Figure 1). Although the deeper searching program versions apparently do not lose more games, they show clear signs of diminishing abilities to win with progressing search depth.

5. EPILOGUE

Among other things in a recent email exchange, Jonathan Schaeffer wrote the following: "Ken's simple experiments certainly spawned a lot of CPU cycles being spent having computer playing computer. The basic conclusions are all the same, but everyone has a different slant on the subject." True indeed – that is exactly why handicap self-play and "go deep" experiments are not going to vanish anytime soon.

Thank you, Ken!

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KEN THOMPSON AND DEEP BLUE

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Ken Thompson had a great influence on the design of DEEP BLUE and on the people behind the machine. DEEP BLUE, the first machine to defeat the World Chess Champion in a regulation match, would not have been possible without his work on BELLE, the first chess machine to play at the national master level. For me personally, he was a teacher not just in technical matters but also in life itself.

1. FIRST CONTACTS

I had no idea who Ken was until I became a Ph.D. student at the CS Department in Carnegie Mellon. I sort of knew what Unix was - one of my best friends in college was in the CS section of the EE Department of National Taiwan University and he had some familiarity with the operating system. At Carnegie Mellon, as a first-year Ph.D. student, I was given a full set of the UNIX manuals at the start of the *Immigration Course*, a one-month intensive course to familiarise the incoming students with the CS Department and teach them how to survive and prosper. Ken's name was in the manuals, but his name really registered in my mind only after my office mates, Mike Brown and Andreas Nowatzyk, and I became close friends. Mike used to play chess competitively in high school and Andreas had served as a referee at a World Microcomputer Chess Championship back in Germany. Given that I had a passing interest in computer chess from undergraduate years[2], it was natural that we had a few conversations on computer chess. Andreas revealed that he attended a talk given by Ken on BELLE in Hamburg. He also mentioned a story of some computer chess enthusiasts trying to buy a copy of the BELLE chess machine from Ken. Ken did not have the time to build a new copy but was generous enough to offer the enthusiasts the schematics of BELLE for free so that they could build a copy themselves. I don't know whether the story is valid, but it left quite an impression.

Andreas and I were both in the VLSI group under Professor H.T. Kung, so it should not come as a surprise that our computer chess conversation drifted to the topic of what effects hardware speed had on a chess program's performance. Mike and Andreas were well aware of the strong correlation between hardware speed and chess playing strength. The then recent result from Ken's self-play experiments on BELLE showed that every six-fold increase in speed (one additional ply) was worth about 200 rating points. Jim Gillogly had earlier done similar experiments using the chess program TECH, but Ken's experiments extended the empirical relationship all the way to the national master level and beyond. One idle question that we asked ourselves was whether a thousand copies of BELLE working together would be sufficient to beat the world champion. Our consensus was that the Belle cluster would be very strong but probably not strong enough.

In early 1985, I was preparing my thesis proposal on an idea for a VLSI-based printer controller that could print complicated Asian characters. Dr. Hans Berliner approached me, asking me to help him with HITECH's evaluation function. HITECH was a chess machine that he and a group of graduate students were working on. I was busy, but agreed to look into his problem if it was not going to take more than a small part of my summer. I thought that it might be a good diversion from my thesis work under Kung. A week later, I finished the top level schematics of the design and gave a presentation to the HITECH group, informing them the good news and the bad news. The good news was that it was doable, and the bad news was that it would use a lot of board space, need an external bipolar adder tree and be relatively slow, given the 64-chip partitioning as in the HITECH 64-chip chess move generator. Nobody was happy. Berliner wanted me to move the external bipolar adder tree onto the NMOS chips. I explained that the circuit would be even slower and making the change would mean I would be spending more than the allocated time.

The night after the presentation, I had a eureka moment. Joe Condon and Ken had written a paper on the BELLE hardware and I had a copy of the paper in my apartment. After going over what happened that day, I decided to take a second look at the paper and was shocked to find that there was a way to modify the BELLE design so

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[2] See the Appendix in the book *Behind Deep Blue*, Feng-Hsiung Hsu, Princeton University Press, to appear in 2002.

that single chip chess machines were almost within reach. In particular, instead of a 64-chip chess move generator that HITECH used, a single chip chess move generator could be built with the MOSIS (MOS Implementation Service) semiconductor processes available to university students at the time. I lost all interest in Berliner's 64-chip evaluation function, told him my discovery, and offered to do a single chip partial evaluation function instead. He was only interested in the 64-chip evaluation function.

During a one-month vacation in Taiwan to look up Chinese literature on calligraphy and fonts for the thesis project, I started thinking of the question that was asked years ago about a thousand copies of BELLE. The more I thought about it, the more I realised that I might have a chance to make history, or at least an incredibly fast chess machine. After some soul searching, I decided to take the plunge. As a first step, I would build a single chip chess move generator when I got back.

Kung agreed to let me work on the single chip chess move generator on a provisional basis - if things did not work out, I would get back to my original thesis topic. I had a very short time to finish the chip, and to motivate myself, I promised myself to complete the chip design in 6 months. Surely, if Joe and Ken could build BELLE in six months, I could build my move generator in the same time.

The logic design of the chip was completed in one month, and by the end of the fourth month, all the core cells were laid out. I was feeling good and getting bold. Out of nowhere, I sent an email to Ken asking him to be on my thesis committee. I did not bother to tell him that the committee did not exist yet. Ken was sufficiently intrigued and asked to see the technical report I wrote on the modified BELLE design before agreeing to my request. Ken thus became the first member besides Kung, who was an automatic member, on my committee. It took another year before the remaining positions on my committee were filled.

The move generator was completed in 6 months as planned, but only after giving up weekends and working long hours into the nights. Ken is a night owl. Did he work long hours into the daytime during the construction of BELLE?

2. COMPETITIONS

The first time I saw Ken face to face was at the 1986 ACM Computer Chess Championship. Ken was not quite what I expected, but in hindsight, he was. His previous responses to my emails had always been short and to the point. He also never capitalised the sentences. Here was a man who knew what was important to him. Everything spurious was kept to the minimum. It turned out that he carried this philosophy to how he dressed as well. Normally, I would expect a Turing Award winner to be a sharp dresser. Ken dressed more like a furniture mover, and was built like one; no wonder he said that BELLE was transportable in his paper. Throughout my years of contacts with him afterwards, I have only seen him dressed formally once - in his wedding photo.

The other surprise was that Ken was not at the Championship as a competitor. He was there as a tournament official, but when CRAY BLITZ had to pull out of the tournament because of lack of computer time, BELLE was drafted to play and ended up winning the title. BELLE played once more the next year, but then retired from computer chess competition permanently. Why did Ken stop playing while BELLE was obviously still a contender? I don't have an answer but I think a story told by Jonathan Schaeffer in his book on CHINOOK, his world championship level checkers program, holds the hint. Jonathan found that Ken withdrew his own checkers program from the Computer Olympiad when he saw Jonathan had already entered. Incredulous, Jonathan asked why. He paraphrased Ken's reply, "he said something to the effect that he'd won enough times in the past with BELLE, and he didn't want to do anything that would interfere with my winning chances."

At the 1986 ACM, we were a nonentity - CHIPTEST was a 7-week-old project with a buggy chip tester and crude chess machine built with no budget by a group of graduate students, and I was able to listen in on the conversations between the other researchers without drawing attention. One of the subjects that came up was how to balance the desire to share information with the rigor of the competition. Some people opted to share nothing to improve their chance of winning. No one was willing to share everything - computer chess was a very competitive field, and probably still is. Ken's solution seemed to strike the right balance. I am not sure I heard it from him or from a third party. He did not volunteer information, but if you asked the right question, he would give you the answer he had found. Among the top contenders, his attitude was probably the most open one.

The next year at the 1987 ACM, Ken, Jonathan, and I had an interesting conversation about what was happening in the chess world. Zsuzsa Polgar had just become very well known. Ken mentioned that the Hungarian chess federation had blacklisted her for years, not allowing her to play in elite tournaments despite invitations from abroad. He and a few friends started a letter writing campaign that eventually broke the blockade. It was a side of Ken that I did not normally see.

The CHIPTEST team won the ACM title in 1987. The following year, we completed DEEP THOUGHT, the first chess machine to achieve Grandmaster level performance over 25 consecutive games. IBM took an interest in the project and hired several of us to continue the project at IBM Research.

3. NO PROGRESS

BELLE influenced the design of DEEP BLUE and its predecessors, but most of the influence was already embedded in the early hardware when members of the DEEP THOUGHT team moved to IBM in 1989.

Thomas Anantharaman, our main programmer, left the team in 1990, and I took over the writing of software for DEEP THOUGHT II, our next machine, for about a year. By 1992, Joe Hoane had joined the team and taken charge of the code and I went back to hardware design. One of the problems that I worked on was the problem of hardware repetition detection. Even DEEP THOUGHT II, searching up to 7 million positions/sec but without repetition detection for the last few plies, was having difficulty solving some of the repetition related quiz positions from the *Encyclopedia of Chess Middlegames*. I found a hardware partial solution that could also be implemented in DEEP THOUGHT II's software.

The partial solution works as follows. If we assume that the player will try to reach a *good* position as soon as possible, then whenever we reach a position that could have been reached in one move (more precisely, in one ply) from an earlier position in the current search path, we can declare that the side that just moved has no better than a draw. The player has the choice to reach the current position earlier and yet decides not to[3]. This is what I call the *no progress* heuristic. The basic assumption behind the heuristic is of course not always correct. If the opponent is not perfect, then we might want to play a testing sequence first deliberately to see whether the opponent will fall into a trap somewhere. Our ultimate opponent would be close to perfect, so the flaw of the basic assumption was deemed acceptable. Besides, we did not really have good ideas on how to get a program to set up traps.

The software version of the no progress heuristic was added into DEEP THOUGHT II after we had a particularly embarrassing game that we did not win against GM Bent Larsen during our trip to Denmark. The 1996 version of DEEP BLUE did not have hardware repetition detection, so it inherited the no progress heuristic software from DEEP THOUGHT II. The 1997 version of DEEP BLUE used on-chip hardware instead.

Ken served as the independent observer at both matches between DEEP BLUE and Garry Kasparov. During the 1996 match, Joe mentioned to Ken that we were doing something extra with respect to repetition detection, but did not explain what it was. Ken somehow figured out the no progress heuristic by himself. Everyone on the DEEP BLUE team was amazed. It was one of the little secret recipes that we had, and yet Ken figured it out from a casual conversation.

Looking back though, I know precisely why Ken had no problem figuring it out - in some sense, the idea came from the BELLE paper in the first place. In the paper, Joe and Ken cited the program not making progress as the reason for declaring one-fold repetition a draw. I remembered making a mental note when I read the reasoning. The no progress heuristic is a direct result of extending the reasoning beyond just one-fold repetition.

After all those years, one of the new things that we discovered turned out to be an old thing. We were dwarfs on a giant's shoulders!

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[3] Say you have a search path that goes something like ...*A*...*BC*, that is, going through position *A* and ended with position *B*, followed by position *C*. If at position *A*, you can reach position *C* in one move with the same side to move, then the side that just moved from *B* to *C* has no better than a draw. It is not a repeated position, hence the phrase "no progress".

KEN THOMPSON'S 6-MAN TABLES

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ABSTRACT

Ken Thompson recently communicated some results mined from his set of 64 6-man endgame tables. These list some positions of interest, namely, mutual zugzwangs and those of maximum depth. The results have been analysed by the authors and found to be identical or compatible with the available or published findings of Karrer, Nalimov, Stiller and Wirth.

1. INTRODUCTION

Thompson has recently created 64 pawnless 6-man endgame tables (EGTs) of btm positions, computed as usual to the Depth to Conversion (DTC) metric and published on the web (Thompson, 2000). Exceptionally, he also computed a KRNKNN EGT to Depth to Mate (DTM) which holds the record for the deepest available EGT.

Each EGT was mined for its list of maximal depth and mutual zugzwang[3] positions; these results were generously communicated to the authors to be analysed further. The second author's manual efforts were duplicated and completed by the first author's programs which also referred to Nalimov's EGTs.

Table 1 lists known data for the endgames and *Bishop-signature sub-endgames*[4] (indicated by a *b*):

- notation: *o* – obtrusive force[5], *s* – also computed by Stiller (1991, 1996), *n* – Nalimov EGT available,
- the maxDTC figure and the number of distinct maxDTC positions, wtm and/or btm, and
- the number of distinct mzugs, the maxDTC of an mzug, and the number at maxDTC

As is customary, the table is based on a set of positions which exclude only those illegal positions with the side not to move in check. Some unreachable positions remain: any affected data can be decremented to correspond to purely legal positions. Where a set of btm positions has not been identified, upper-bounds, anticipating possible duplicates, for the number at maxDTC have been derived from provided distribution data. The maximal and mzug data, including complete sets of positions for each endgame, is available on the web's evolving endgame site (Tamplin, 2001) with DTM figures from Nalimov EGTs where available.

No *full point mzug* – Black winning with wtm – has been found. Other early observations about the endgames:

- KBBNKR: the two btm maxDTC positions are unreachable (Conrady, 2001),
- KQQKRB: two of the four maxDTC positions (bR a2/4) are unreachable (Conrady, 2001),
- KQRKQR: Stiller (1996) remarks on the "surprising" maxDTC of 92,
- KRBKBN: the won wKe2Bh7Rg2/bKa6Ng5Be7+121w was drawn, DEEP FRITZ – DEEP JUNIOR[6],
- KRNNKQ: maxDTC wKc7Rh2Na2b3/bKa6Qd1+w identified as a deep study (Elkies, 2000),
- KRRRKQ: DTC-minimaxing, Bl. loses wKd8Rb1g1h4/bKf7Qb3+b after 59 checks (Conrady, 2001).

The isolation of information for Bishop-signature sub-endgames is an innovation. For Bishop-signature sub-endgames which do not contain a maxDTC position for the complete endgame, the number of maxDTC wtm positions is not known. In eleven cases, the maxDTC for wtm positions is also not known. Thompson also confirms results by Karrer and Wirth (Tamplin, 2001) for some 11 4- and 5-man EGTs.

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[3] also *mzug*: here, as Ken records only "White wins or does not", a position where White wins with btm but not with wtm.

[4] *e.g.* KBBNKB-efgh has e/g (f/h) White/Black Bishops on one (the other) colour of square; $e \geq f$ but if $e = f$, $g \geq h$.

[5] force beyond that initially present on the board, e.g. a second Queen or white-square Bishop, or a third R/B/N.

[6] Match in 2001 to determine the chess engine to challenge Kramnik later this year: game 13, move 121w.

Our thanks to Ken Thompson of course, to Noam Elkies for extracts from his archive of Stiller summary data, to John Roycroft for a 1992 Noam Elkies' note on Stiller's results, to Helmut Conrady for observations, and to Eugene Nalimov, Peter Karrer and Christoph Wirth for their corroborating work on 5-man EGTs.

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Endgame				maxDTC		# @ maxDTC			mzugs		
Title	GBR code	w-b	o b s n	wtm	btm	wtm	btm		# of	max	# @
						=	=	≤	mzugs	DTC	maxDTC
KQKBBB	1090/03	2-4	o s	51	51		1		463	38	1
KQKBBB-0021	1090/03-0021	2-4	o b s		39		14		392	35	1
KQKBBB-0030	1090/03-0030	2-4	o b s	51	51		1		71	38	1
KQKBBN	1063	2-4	s	63	62	1		17	3290	59	1
KQKBBN-0011	1063-0011	2-4	b s		51		7		1305	46	1
KQKBBN-0020	1063-0020	2-4	o b s	63	62	1		17	1985	59	1
KQKBNN	1036	2-4		49	49		1		3779	37	4
KQKNNN	1009/03	2-4	o s	35	35		6		2886	25	1
KBBKNN	0026	3-3	n	38	38		1		817	25	1
KBBKNN-1100	0026-1100	3-3	b s n	38	38		1		817	25	1
KBNKNN	0017	3-3	n	13	12	1	1		402	8	8
KNNKNN	0008	3-3	n	7	6	44		8	32	1	32
KQBKQB	4040	3-3	s	46	45	2		3	21	7	1
KQBKQB-1001	4040-1001	3-3	b s	30	29			?	13	7	1
KQBKQB-1010	4040-1010	3-3	b s	46	45	2		3	8	4	1
KQBKQN	4013	3-3	s	36	36		1		76	10	1
KQBKQR	4310	3-3	s	32	31	3		5	6	4	1
KQBKRB	1340	3-3		42	41	2		10	16	12	3
KQBKRB-1001	1340-1001	3-3	b	42	41	2		10	7	12	3
KQBKRB-1010	1340-1010	3-3	b		22		83		9	10	1
KQBKRN	1313	3-3		27	27		6		15	15	2
KQBKRR	1610	3-3	s n	85	84	1		79	158	70	1
KQNKQB	4031	3-3	s	32	32		3		34	15	1
KQNKQN	4004	3-3	s	29	29		3		149	11	2
KQNKQR	4301	3-3	s	27	26	6		2	3	3	1
KQNKRB	1331	3-3		26	26		19		88	18	1
KQNKRN	1304	3-3		40	40		1		123	20	1
KQNKRR	1601	3-3	s n	153	153		6		905	137	2
KQQKQQ	8000	3-3	o s n	44	44		1		8	14	1
KQQKQR	5300	3-3	o s n	48	47	3	1		15	15	1
KQQKRB	2330	3-3	o n	14	13	4		28	0	---	0
KQRKQB	4130	3-3	s	73	73		12		1359	56	1
KQRKQN	4103	3-3	s	71	71		4		1722	48	1
KQRKQR	4400	3-3	s	92	92		1		236	40	1
KQRKRB	1430	3-3		21	21		10		1	1	1
KQRKRR	1700	3-3	n	34	34		4		5	11	1
KRBKBB	0170	3-3	n	83	83		3		376	73	1
KRBKBB-1002	0170-1002	3-3	o b n	83	83		3		120	73	1
KRBKBB-1011	0170-1011	3-3	b s n	75	74		2		90	68	1
KRBKBB-1020	0170-1020	3-3	o b n	49	48		4		166	36	1

Table 1a. Data on Thompson's 6-man EGTs, Part 1.

Endgame				maxDTC		# @ maxDTC			mzugs		
Title	GBR code	w-b	o b s n	wtm	btm	wtm	btm		# of	max	# @
						=	=	≤	mzugs	DTC	maxDTC
KRBKBN	0143	3-3	s	98	98		6		1456	79	1
KRBKBN-1001	0143-1001	3-3	b	98	98		6		23	79	1
KRBKBN-1010	0143-1010	3-3	b		64		4		1433	50	1
KRBKNN	0116	3-3	s n	223	222	1		2	203	213	1
KRBKRB	0440	3-3		17	16	4	1		11	7	1
KRBKRB-1001	0440-1001	3-3	b	17	16	4	1		4	5	1
KRBKRB-1010	0440-1010	3-3	b	12	11		9		7	7	1
KRBKRN	0413	3-3		21	20	62		26	96	13	1
KRNKBB	0161	3-3	s n	140	140		9		801	133	1
KRNKBB-0011	0161-0011	3-3	b s n		52		8		253	42	1
KRNKBB-0020	0161-0020	3-3	o b s n	140	140		9		548	133	1
KRNKBN	0134	3-3	s	190	189	1		7	7933	180	1
KRNKNN	0107	3-3	s n	243	242	1		7	8997	226	2
KRNKRB	0431	3-3		14	13	25		2	7	5	2
KRNKRN	0404	3-3		21	20	5		2	69	11	1
KRRKBB	0260	3-3	n	37	37		16		15	21	1
KRRKBB-0011	0260-0011	3-3	b s n	37	37		16		13	18	1
KRRKBB-0020	0260-0020	3-3	o b n		26		92		2	21	1
KRRKBN	0233	3-3	n	26	25	3		42	57	17	2
KRRKNN	0206	3-3	n	33	33		3		41	22	1
KRRKRB	0530	3-3	s n	54	54		13		499	41	2
KRRKRN	0503	3-3	s n	73	73		3		697	50	1
KRRKRR	0800	3-3	s n	18	17	2		3	4	6	2
KBBBKB	0090/31	4-2	o	20	20		4		0	---	0
KBBBKN	0093/30	4-2	o	12	12		8		0	---	0
KBBBKR	0390/30	4-2	o s	69	68	1		23	8	61	1
KBBBKR-2100	0390/30-2100	4-2	o b s	69	68	1		23	8	61	1
KBBNKB	0051	4-2		36	36		4		23	24	1
KBBNKB-1110	0051-1110	4-2	b		29		106		1	18	1
KBBNKB-2001	0051-2001	4-2	o b	21	20		22		9	6	1
KBBNKB-2010	0051-2010	4-2	o b	36	36		4		13	24	1
KBBNKN	0024	4-2	s	31	31		54		29	26	1
KBBNKN-1100	0024-1100	4-2	b s		13		70		0	--	0
KBBNKN-2000	0024-2000	4-2	o b s	31	31		54		29	26	1
KBBNKQ	3021	4-2		12	11	109		15	17	4	5
KBBNKQ-1100	3021-1100	4-2	b s	12	11	109		15	17	4	5
KBBNKQ-2000	3021-2000	4-2	o b	7	6		12		0	--	0
KBBNKR	0321	4-2		68	68		2		337	54	2
KBBNKR-1100	0321-1100	4-2	b s	68	68		2		80	54	1
KBBNKR-2000	0321-2000	4-2	o b	66	65		8		257	54	1
KBNNKB	0042	4-2		38	38		2		124	27	1
KBNNKB-1001	0042-1001	4-2	b		32		8		15	25	1
KBNNKB-1010	0042-1010	4-2	b	38	38		2		109	27	1
KBNNKN	0015	4-2		27	27		54		91	22	1
KBNNKR	0312	4-2	s	49	48	12		4	628	37	1
KNNNKB	0039/30	4-2	o s	92	91	1		2	1009	66	1
KNNNKN	0009/31	4-2	o s	86	86		2		2115	78	2
KNNNKR	0309/30	4-2	o	12	11	2		2	82	5	1
KQNNKQ	4002	4-2	s	72	72		2		1082	57	1
KRBBKQ	3120	4-2		44	44		1		222	36	2
KRBBKQ-1100	3120-1100	4-2	b s	44	44		1		192	36	2
KRBBKQ-2000	3120-2000	4-2	o b		15		2		30	7	2
KRBBKR	0420	4-2		36	35	1		20	10	18	1
KRBBKR-1100	0420-1100	4-2	b		27		75		5	15	1
KRBBKR-2000	0420-2000	4-2	o b	36	35	1		20	5	18	1
KRBNKQ	3111	4-2	s	99	98	4		3	983	92	1
KRNNKQ	3102	4-2		28	27	2	1		198	14	1
KRRBKQ	3210	4-2	s	82	82		4		191	56	1
KRRNKQ	3201	4-2	s	101	101		2		739	86	1
KRRRKQ	3900/30	4-2	o s	65	65		5		1	17	1

Table 1b. Data on Thompson's 6-man EGTs, Part 2.

RETROGRADE ANALYSIS: SOFTWARE ARCHITECTURE

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ABSTRACT

This is a retrospective on aspects of error-detection and development protocols in the architecture of the author's retrograde analysis software with particular reference to the influence of Ken Thompson.

1. INTRODUCTION

Ken Thompson's work on the retrograde analysis of 5-piece chess endgames (Thompson, 1986) demonstrated that deep surprises lurked in seemingly simple positions. That work was the foundation and motivation on which future endgame tables have been constructed and sparked my own interest in the field (Stiller, 1989).

I implemented a modified version of the Thompson algorithm on Connection Machines and some serial machines and obtained results for certain 6-piece endgames. The specific algorithmic changes to the Thompson algorithms were as follows (Stiller, 1991):

- The set of White-to-win-in-k+1 moves is the predecessors of the complement of the predecessors of the complement of the set of White-to-win-in-k moves, modulo stalemate. Thompson's backup rule was different.
- Piece motion in the space of endgames corresponds to movement along a plane of a hypercube, where we associate a position in a 6-piece endgame with a point in a *hyperboard*, the cross-product of 6 chessboards. This method can be viewed as a 12-dimensional analog of the sliding-piece move generation in Thompson's well-known BELLE computer (Condon and Thompson, 1982, 1983).

The first observation allows for efficient parallel decomposition; the second for efficient communication. These modifications also make the algorithm suitable for high throughput in a vector or superscalar single-CPU architecture.

2. SOFTWARE ARCHITECTURE

The architectural challenge was to meet two objectives: produce optimized code and reliably produce correct results in which we could have confidence. The environment for doing so was less than ideal:

- the Connection Machine supercomputer hardware was much in demand,
- a run could take an unpredictable number of hours as it was not clear how deep each endgame was,
- lack of disc space meant that it was not possible to have much interactive access to the results,
- there was therefore no opportunity to debug code results directly on the CM computers,
- new code was required to go from 4-man to 5-man, and from 5-man to 6-man endgames,
- any hardware or software bug would likely invalidate all the results.

The last observation underlined the challenge, especially as some 12,000 lines of code were to run on esoteric hardware; most workers in this field had commented on the ease with which bugs could creep into the code. To achieve the objectives above, the program P was partitioned into $P \equiv X + Y \equiv L + R + Y$. Here X is the front-end and Y the back-end code. X manages the movement of bits within the hyperboard: $X \equiv L + R$ where L determines the appropriate matrix factorization (Stiller, 1994) and R determines resource management (primarily memory allocation). Y actually moves the bits in the hyperboard, performing the matrix multiplication.

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For example, X might issue the instruction "tilt the hyperboard to the left in dimension 5" and Y would then move the resulting bits residing in the memory of the physical processors.

Calls to machine primitives by Y were isolated and replaced by stubs. Each stub validated its arguments and maintained statistics on its memory usage and how many times it was called with which size data.

A simulated run was obtained by linking P with the stub library, guessing a number-of-moves-to-win n and running the simulation as if the main fix-point loop terminated after n iterations. This verified validity of each argument to each machine primitive used to move hyperboard bits and allowed code to be modified until required memory and time constraints were met (i.e., R is checked).

To check L, P was compiled against a 4×4 board and the result linked to the real library, enabling X to send similar sequence of instructions to Y. These runs could be debugged directly and extensive analysis of the 4x4 6-piece games was performed. The ability to run simulations on any Unix workstation was one of the main reasons the code was developed in pure C rather than Lisp, which had at the time a higher-level interface to the CM hardware.

Transient hardware faults were detected through multiple runs, typically with different mapping geometries from the hyperboard onto the physical RAM.

By altering the factorization slightly the code was ported to single-CPU superscalar architectures. In this case, for end-user applications such as when the endgame tables were used by strong chess computers, disk I/O reliability was a potential concern, so all disk I/O was checksummed. In addition, the batch processes that computed these obeyed a locking protocol to check that all writes of files to the disk system were atomic. In this way, any transient single point of failure, disk, RAM, or CPU, should not have resulted in erroneous output.

The results were confirmed by Thompson's recently published 6-piece web endgame tables (Thompson, 2000; Tamplin and Haworth, 2001). That data is more accessible than the author's generated data, and I have used it to analyze endgame studies (Van der Heijden, 2000), including one which was cooked by a win in 211 moves (Stiller, 2001).

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ENDGAME TABLES AND ENDGAME STUDY COMPOSITION

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ABSTRACT

The endgame tables (EGTs) of Thompson and others have helped composers, tourney directors, judges and cook hunters check the correctness of endgame studies. Further, but only recently, EGTs have assisted the act of composition, for example, by being mined for their lists of mutual zugzwangs. This paper identifies further challenging opportunities for computers to contribute to study composition, even to the complete composition of a study indistinguishable in a 'Turing Test' from one originated by a composer.

1. INTRODUCTION

Despite the popularity of endgame studies[2] in Arab countries in the 9th and 10th centuries (Hooper and Whyld, 1996), it is generally accepted that Kling and Horwitz's *Chess Studies* (1851) marks the birth of modern endgame study composition. Kling and Horwitz's book contains more than 200 positions. Although the authors in their preface state that these positions were intended for didactic purposes, a large number of the endings are to be considered as artistic endgame studies. It is clear that endgame theory was important for endgame study composition right from the start. Therefore, the introduction of EGTs is very important, as illustrated with a few examples in this article.

2. THE KBBKN EGT

One of the most important positions in *Chess Studies* is given in Diagram 1 (Kling and Horwitz, 1851). This position used to be referred to as the Kling and Horwitz fortress for this ending. Kling and Horwitz state: "Kt. and B. against B. cannot win, if the weaker party can obtain a position similar to the above, but they win in most cases." In a later edition of this book (Horwitz, 1884), this error is corrected: "Two Bishops against a Knight cannot win, if ...".

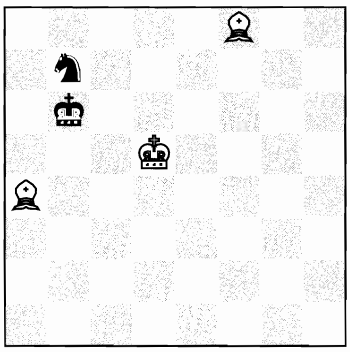

Diagram 1: K&H fortress (1815)
White to move.

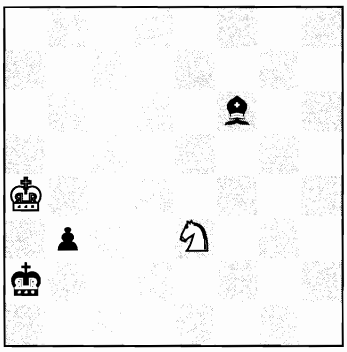

Diagram 2: Boniface-Pugh (1995)
Black to move.

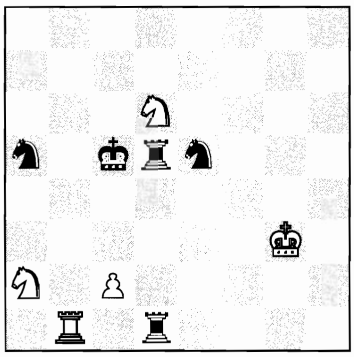

Diagram 3: Em. Lasker (1893)
White to move draws.

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[2] cf. Beasley and Whitworth (1996) for an excellent introduction to endgame studies.

However in 1972, Roycroft (1972) raised a doubt, showing a way to force black King and Knight out of the fortress: 1. Be7 Kc7 2. Bh4 Kb6 3. Bg3 Na5 4. Bf2+ Kc7 5. Kc5 Nb7+ 6. Kb5. “But this at least leaves the question open whether Black can take up a comparable position in another corner, ‘though it looks as if he can’.” After Roycroft (1983) recommended that this ending be examined, Thompson constructed an EGT proving that the Kling and Horwitz position is a win.

Suddenly, all endgame studies based on the Kling & Horwitz position were incorrect, although it could be argued that they had, until that time, been correct in the context of accepted theory. Krabbé (1977) compared this situation with a Netherlands-Germany border adjustment of 30 years ago. The night before the change took place, several butter trucks parked on the Netherlands side of the border. The next morning, they were in Germany. The butter had not been smuggled across the border but the border across the butter.

Thompson’s breakthrough gained the attention of the general chess public when this ending appeared in Timman-Speelman, Linares 1992, shortly after adjournment. Timman was able to win the game after studying a number of publications on the computer analysis of this endgame (Breuker et al., 1992; Van den Herik, 1992).

From a composition viewpoint the prettiest example of this ending in practical play is the position in Diagram 2 (Van der Heijden, 1996). After **62. ... b2 63. Nd1 b1=B!!** is the only move to win. After 63. ... b1=Q/R, White has a stalemate trick: 64. Nc3+ B×c3 stalemate. And after 63. ... b1=N the position is a draw. Pugh did not manage to win this ending: the game was agreed a draw on move 92[1]. The same underpromotion had already been used in a study by Källström in 1984 (Van der Heijden, 1996).

3. THE KNNKP ENDGAME

Emanuel Lasker (1893) published the study of Diagram 3. After **1. Rb5+ K×d6 2. R×d5+ R×d5 3. Nc3** the black Rook is dominated and Black is left with two Knights. But then Troitzky (1906) published the first of a series of articles about his findings in the ending two Knights against Pawn, proving that Black wins in this position, e.g., by **3. ... Nac4 4. N×d5 K×d5 5. c3 Ke4**. The analysis of Chapais and incorrect findings of Berger and Von Guretzky-Cornitz inspired Troitzky (1937) for his work.

The Lasker study is usually cited from a secondary source (Halpern, 1905) and had this been the primary source, it would seem that this is another example of an endgame study being cooked by a subsequent theory of the endgame (Korn, 1975; Caputto, 1996). But Whyld (1998) probably gives the prime source and mentions that Babson (1894) demonstrated a black win in 45 moves. The study by Lasker also appeared in the March *Deutsche Schachzeitung* (Anonymous, 1894a), referring without date to the *Dresdner Schachblätter*. The solution was published in July (Anonymous, 1894b) mentioning that a solver, Weinheimer, had found the 3. ... Nac4 cook. Whyld (1998) speculates that this study might have inspired Troitzky’s work, but this is not so likely since Troitzky’s (1906) introductory article gave other, sometimes rather trivial, examples how such an ending could be reached.

4. ENDGAME TABLES AS COMPOSITION TOOLS

The fact that Thompson not only constructed many 5-piece EGTs, but also made them easily available to the general public by distributing them on CD-ROM (Thompson, 1991), has been extremely important for their use in endgame study composition.

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[1] Tim Krabbé (2000) obtained the game score from Paul Butterfield, a fellow member of the two players’ club: “When the Bishop promotion occurred on move 63, Steve Boniface had about 5 minutes left, and Derek Pugh had only 2 minutes, so there is no completely original game score. Steve is, however, a BCF arbiter, and is very used to reconstructing games in this kind of situation, and he thinks it's accurate. 63. Nd1 b1=B 64. Ne3 Be4 65. Kb5 Kb3 66. Kc5 Bf3 67. Nf5 Kc3 68. Kd6 Kd3 69. Ne7 Ke4 70. Nd5 Be5+ 71. Kc5 Bb2 72.Nc7 Ba3+ 73. Kc4 Be7 74. Kc3 Bd6 75. Ne6 Bg4 76. Nd8 Bc7 77. Nc6 Bd6 78. Nd8 Bf5 79. Nf7 Bc7 80. Kb4 Bg6 81.Ng5+ Ke5 82. Kc4 Be8 83. Kc5 Bh5 84. Nh3 Bb8 85. Kb6 Ke4 86. Ng5+ Kf5 87. Nh3 Kg4 88. Nf2+ Kf3 89. Nd3 Ke4 90. Nc5+ Kd5 91. Nd7 Bf4 92. Nf6+ draw.”

Remarkably, the Thompson EGTs were used almost exclusively for the first decade by composers, study tourney judges and cook hunters to check only the technical quality of correctness. Endgame theory, particularly, flourished with many new discoveries based upon the EGTs, brilliantly illustrated by the trilogy of Nunn (1992, 1994, 1995).

Because of the emphasis on correctness checking, it is possible that many composers may not have been very positive about the introduction of the EGTs. Many of their masterpieces had been busted over the years. Was this the end of endgame study composition, like the inevitable end of correspondence chess with the introduction of chess computer programs and their increasing strength?

Only at the end of the 20^{th} century did composers start to recognize the merits of the EGTs. Not only could they use the EGTs as a technical tool themselves but there was more! Rasmussen used his programming skills to extract lists of mutual zugzwang positions from the Thompson EGTs. These lists were published in *EG*. Most of these positions were previously unknown and some were then successfully used by composers in endgame studies.

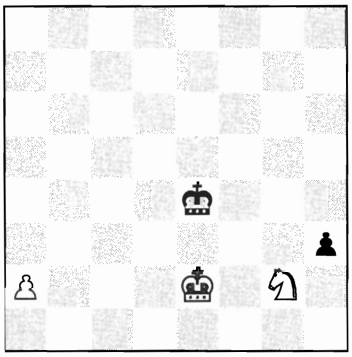

Diagram 4: Beasley (1998) White to move wins.

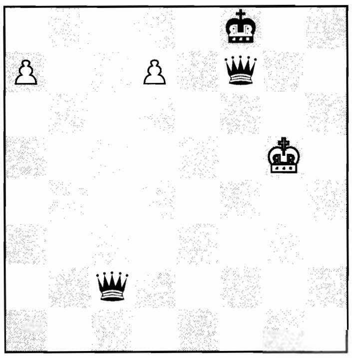

Diagram 5: Karrer & Elkies (2001) White to move wins.

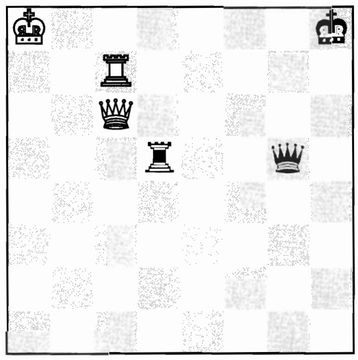

Diagram 6: Van der Heijden (original): White to move wins.

The study by Beasley (Diagram 4) is an example showing how easily composers can find interesting positions in the zugzwang lists. If a position has a Pawn on the 3^{rd} rank, then there is a good chance that when the Pawn is on the 2^{nd} rank, the only way to win is to play the Pawn to the 3^{rd} rank. This theme was named *Festina Lente* (make haste slowly) by the Czech composer Mandler (Mandler, 1960; Beasley, 2000).

After **1. Ne3 h2 2. Nf1** Black plays **2. ... h1=N** (2. ... h1=Q is hopeless: 3. Ng3+ Kd4 4. N×h1 Kc3 5. Nf2 Kb4 6. Nd3 Ka3 7. Nc1). Now White only wins by **3. a3!** (the natural 3. a4? fails to 3. ... Kd4 4. Kf3 Kc4 and the a-Pawn is lost) **3. ... Kf4** (If Black now plays 3. … Kd4, White is able to defend the Pawn: 4. Kf3 Kc3 5. Ne3(d2) etc.**) 4. a4 Ke4** and now White has gained a tempo in comparison with the 3. a4? line! **5. a5 Kd5 6. Kf3 Kc5 7. Ne3(d2)** and again the Pawn will be defended.

It should be noted that this study does not show the mutual zugzwang theme itself, because such a study requires a (thematic) try showing the mutual zugzwang position with White to move. Triangulation is a common feature of mutual zugzwang studies. But the mutual zugzwang theme does occur in combination with the *Festina Lente* theme. Such positions can be easily discovered with the help of a mutual zugzwang list because they should have a white Pawn on the 4^{th} rank.

Apart from the mutual zugzwangs, the EGTs hold many other positions that are very interesting for endgame study composers. Examples are positions where an underpromotion is the only winning (drawing) move, or positions with a long *Unique Move Sequence* (UMS). Generally speaking, there is a need for an EGT interface providing several facilities. For example, to find in a certain EGT particular unique moves, e.g., in the KRKNN database all positions in which the move Ra1-a8 is the only winning move. Another example is to extract from a certain EGT a pattern with unique moves, e.g., to find in the KRKNN database with wKa1, bKa8, bNh1, bNh8 all positions of a wR where White has only one winning move. A further example is to identify UMS in a certain EGT, e.g., to find in the KQBKQ database all UMS longer than xx moves. The difficulty with UMS is that "loss of time"duals (Black can force White to return to the main line; this could be quite complex) or other unimportant duals (e.g., Ra7-a1 wins, but also Ra7-a2 with the same idea) seem to be difficult to handle.

Peter Karrer extracted from the KQPKQQ EGT all positions with a Pawn on d7 where a Rook or Bishop promotion is the only way for White to win or draw. Noam Elkies added an introduction to one of the positions (Elkies, 2001): see Diagram 5.

White wins by **1. a8=Q+! Kg7 2. Qa1+ Kh7 3. Qh1+ Kg8 4. d8=R+!!** (Not 4. d8=Q+? Qf8 5. Qdd5+ Qf7 6. Qd8(a8)+ Qf8 7. Qhd5+ Kh7 8. Q×f8 Qg2+ 9. Kf6 Qf3+ 10. Q×f3 stalemate!) **4. … Qf8 5. Qd5+ Kg7 6. Qd7+ Kg8 7. Qe6+**, and wins.

Diagram 6 is a study that shows a UMS with minor duals that was derived by a trial-and-error method from the KQRKQR EGT and accompanying mutual zugzwang list (Roycroft, 2000b). White wins by **1. Kb7!** (reaching the mutual zugzwang position at once. Not 1. Kb8? Rd8+ 2. Kb7 Rd5 and we have the same mutual zugzwang with White to move. Unfortunately, 2. … Qd5+ also draws here) **1. … Rb5+** (1. … Re5 2. Qd7! Rb5+ 3. Ka6! Ra5+ 4. Kb6! wins, or here 2. … Qg2+ 3. Kb8! winning) **2. Ka7** (2. Ka6 Rd5! 3. Kb7 repeats, as well as 3. Rc8+ Rd8 4. Rc7! Rd5 repeating) **2. … Rd5** (2. … Ra5+ 3. Kb6) **3. Qc3+! Kg8 4. Qb3! Kf8 5. Qb8+! Qd8** (5. … Rd8 6. Qb4+! Ke8 7. Qe4+ Kf8 8. Qf3+ Kg8 9. Qf7+, or 6. … Kg8 7. Qb3+ Rd5 8. Rd7 Qg1+ 9. Kb7, or here 7. … Qd5 8. Qg3+! Kf8 9. Qg7+, and mate) **6. Qb4+! Qd6 7. Rc8+!** (7. Qb8+? Qd8) **7. … Ke7 8. Qh4+! Ke6 9. Qh3+! Ke7 10. Qh7+** (10. Qh4+ Ke6 11. Qh3+ repeats) **10. … Kf6 11. Qh8+** (11. Qh6+ Kf7 12. Qh7+ Kf6 repeats) **11. … Kf5 12. Rf8+** (12. Qh7+ Kf6 13. Qh8+, 12. Qh5+ Kf6 13. Qh8+, 12. Qh3+ Kf6 13. Qh8+, all repeat) **12. … Kg4 13. Qg8+! Rg5 14. Qc4+! Kh5 15. Rh8+! Kg6 16. Qg8+! Kf5 17. Qf7+! Kg4 18. Qc4+! Kg3 19. Qh4+! Kf3 20. Qh1+** (Not 20. Q×g5? Qd4+) **20. … Rg2 21. Qf1+! Rf2 22. Qh3+** (22. Qh1+ Rg2 23. Qf1+ repeats) **22. … Ke2 23. Re8+ Kd2 24. Qe3+** and wins (e.g., 24. … Kd1 25.Qe1+ and Q×f2+). This is a 24-move long UMS with in addition three quiet moves in an endgame with powerful forces. This challenges programmers to identify a longer UMS in an EGT.

Other programming tasks in endgame study composition wait to be attempted, e.g., a program that indexes endgame studies according to theme. Beasley (2001) optimistically estimates that this task would take a competent programmer only two months and adds that it could be a suitable thesis project for a M.Sc. in computer science.

5. DISCUSSION

Some people now argue that all endgame studies with at most five men are anticipated by the Thompson EGTs, because all positions and lines are present in these databases and are published. An argument against this point of view is that an endgame study is an artistic product, and that only a human being can decide that a position with its unique moves is an endgame study.

The studies subcommittee of the FIDE PCCC issued a proposal to organise separate tourneys for EGT-derived endgame studies and for conventionally composed endgame studies (Roycroft, 2000a). Their argument for doing so is that the skill needed to extract studies from an EGT are distinct from those needed for traditional study composing and that judges have been faced with the "insurmountable difficulty" of distinguishing between these types of compositions. For several reasons these guidelines are not very useful in their present form. Firstly, the only real purpose of endgame study composition is to create something beautiful. Why care about the method? Secondly, other differences in skill have never been considered very important (e.g., study composition by an o.t.b. GM versus a moderate o.t.b. player) in endgame study composition. Thirdly, for other aspects of endgame studies (win/draw studies, twins, miniatures, styles) the same problem of inequality arises. Judges need to be competent to recognize and value EGT-derived studies. Or is endgame study composition using the Thompson EGT a Turing test?

To conclude, the best illustration of Thompson's magnificent contribution to our endgame world is the remark John Beasley (1998) included in his obituary of David Hooper: "... at the end, when a chess library which had once occupied most of a wall was reduced to five books on a nursing-home mantleshelf, three of the five he had kept were the Nunn books expounding the Thompson database discoveries."

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ENDGAME TABLES AND CHESS COMPOSITION

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USA

ABSTRACT

This paper places Ken Thompson's work on computer-generated endgame tables in a historical progression of "retrograde analysis" of chess endgames, a progression comprising human efforts as well as computer work of greater accuracy and ever-increasing computational power. The paper shows how Thompson's and others' endgame tables have made and can continue to make a particularly significant contribution to the art of the chess endgame study.

1. INTRODUCTION

Chess, like almost every other facet of our culture, increasingly feels the influence of computer technology. The computer's effect on chess studies and problems was treated, at greater length and scope than is possible here, in Elkies (1994). Here I shall concentrate on the effect of computer-generated Endgame Tables (EGTs) obtained by the exhaustive retrograde analysis[2] (RA) of a restricted class of positions. This topic is doubly timely. First, the present issue of the *ICGA Journal* celebrates Ken Thompson, who played a central role in compiling and disseminating EGTs. Secondly, the use of such data in the composition of some chess studies has prompted sweeping and, in my view, ill-considered recommendations that would discourage such studies by penalizing or excluding them from composition contests. After briefly placing EGTs in their chess context and describing Ken Thompson's contribution to their present state, I introduce chess studies and other compositions, illustrate how EGTs can affect their creation and analysis, and consider what if anything ought to be done about it.

2. RETROGRADE ANALYSIS

The idea of RA is by now familiar to every reader of this issue of the *ICGA Journal*. Perhaps less familiar is the history of RA long before the computer age, and recognition of the RA principle as a basic strategy for humans to learn and play chess.

The object of the game is to checkmate your opponent, or failing that to avoid getting mated yourself. When (as usually happens) this goal is too distant to pursue directly, we aim for intermediate goals such as material advantage. How much material is enough? We quickly learn that (barring immediate stalemate) King and Queen or King and Rook easily force mate against a bare King, but King and Bishop or Knight cannot checkmate even with the opponent's help. Two Bishops can mate without much difficulty. Mating with Bishop and Knight, or two Knights, is harder. In either case one can construct mating positions, but can the lone King be forced into one of them? A bit of elementary RA disposes of the two-Knights ending: unless the stronger side has mate on the move, checkmate cannot be forced at all. With Bishop and Knight, mate can be forced only near the two corners of the same color as the Bishop; further pursuing the analysis in either retrograde or direct mode, one eventually finds that the bare King can be marched to the gallows from almost any initial position, but the procedure is remarkably arduous and usually not learned until long after a chess player has mastered the basic mates with Queen, Rook, and two Bishops.

Leaving the intricacies of KBNK aside, we first learn to deal with Pawns. King and Pawn cannot checkmate a bare King directly, so the Pawn aims to promote to a Queen. We learn about the 'square of the Pawn', the 'opposition', and the special liability of rook Pawns; and we learn that the Kings must often duel for position before the Pawn can advance. Only once we have mastered the ending of King and Pawn versus King can we begin to understand more complicated endings with Pawns, such as White's drawing combination in the position of Diagram 1 (Mattison, 1918).

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[2] The phrase *Retrograde Analysis*, used here to describe the retro-generation of EGTs, is also used elsewhere to refer to the analysis of retro- or "what happened before?" problems.

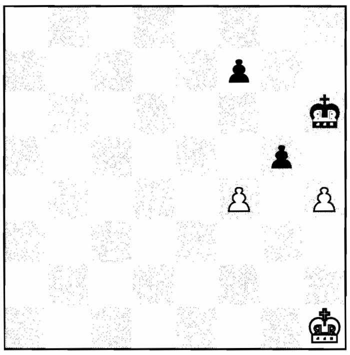

Diagram 1: Mattison (1918), wtm and draw.

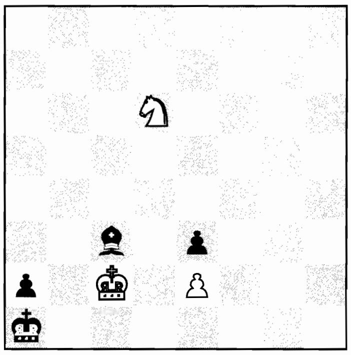

Diagram 2: Elkies (1987), Wh. wins, btm.

White is about to capture Black's g5-Pawn and then lose both of his Pawns. But he has considerable choice in how to do this, and one narrow path leads to a drawn Pawn-down ending:

1. h×g5+! Kh5 2. g6! f×g6 (K×g6? 3. Kg2 and holds the Pawn) **3. f5! g×f5** (Black has the "distant opposition", but...) **4. Kg1! Kg5 5. Kf1!** and since the Pawn prevents 5. ... Kf5 which would keep the opposition, Black must acquiesce in **5. ... Kg4 6. Kg2** or **5. ... Kf4/Kh4 6. Kf2** and White has reached a theoretical draw.

This draw by 'opposition' or 'corresponding squares' is a typical instance of human RA. We first see that the position wKf2/bKf4Pf5 is lost wtm (if Kg2/Ke2 then Ke3/Kg3 wins), and then that wKg2/bKg4Pf5 too is lost wtm (as 1. Kf2 Kf4 produces a known Black win). Then, having also learned already that advancing the Pawn only draws, we see that both the wKf2/bKf4 and wKg2/bKg4 positions are only draws btm, and hence are mutual zugzwangs. Only then do we understand 5. Kf1!. Similar remarks apply to the analysis proving that White loses after 1. f×g5+? Kh5 or 1. h×g5+ Kh5 2 Kg2? Kg4.

In principle, one can continue in this fashion to more complicated endings, and even the middlegame and the opening array, identifying each position as a forced win for White, forced win for Black, or forced draw with best play. But in practice it is impossible to definitively assign a typical middlegame position, let alone the opening array, to one of these classes: the necessary computation, though finite, is so large as to utterly dwarf the Earth's total computing power for the foreseeable future. Endgame considerations certainly affect middlegame and even opening strategy, but not nearly in so precise a way as to merit the label of RA except metaphorically.

Human brainpower too is hopelessly defeated by the task of completely solving chess — which is just as well, since we derive inexhaustible challenge and pleasure from the game. Still, human RA can go much further than the examples we have seen so far. We already mentioned the opposition, which controls a duel between two Kings. Other duels can also be solved by RA, often with more mysterious-looking results.

Consider for instance the position of Diagram 2. This is essentially a duel between the Knight and Bishop over access to the mating square b3. White will win if his Knight can safely reach c1, d4, a5, or c5, or capture e3 (when the White Pawn can advance decisively while the Bishop is tied down); to draw, Black must prevent this indefinitely.

For instance, Black must always answer Nb7 with Bb4 to cover both a5 and c5, and answer Kc1 with Ba3+/Bd2+, Kc2 Bb4 — which is why Bb6 is not good enough. Likewise Nc6 must be met with Bc3 (and not Bb6, again because of Kc1); then Nd8 must be answered with either B×d8 or Ba5 (and not Bd2/Be1 because then Ne6 mates in two via d4 or c5); and so forth. It took about an hour of human processing to work through the RA and reach the diagrammed position. Like the position with wNb7/bBb4, but for much less obvious reasons, the wNd6/bBc3 position is mutual zugzwang: White wins only if Black is to move.

If White is to move, Black can keep the Knight at bay, for instance **1. Nf5 Bd4!** when **2. N×d4** would stalemate, or **1. Nc4 Bd2 2. Nb6 Bc3/Bb4 3. Na4 Bd4/Bc5**, or **1. Nb7 Bb4 2. Kc1 Ba3+/Bd2+! 3. Kc2 Bb4 4. Nd8 Ba5! 5. Ne6 Bb6! 6. Nf4 Bc5! 7. Nd5 Bd4! 8. Nb4 Bb2! 9. Nd3 Ba3!** (all of Black's moves here are unique) and so forth. With Black to move, White can win by force, though it can take 11 unique moves and several more mutual zugzwangs (marked by z): **1. ... Ba5 2. Nf5 Bb6 3. Ne7 Bd4** [or 3. ... Ba5 4. Nd5 Bd2 (Bb6 5.

Nb4 and 6. Nd3/Nc6) 5. Nf4 Bb4 transposing to the position after Black's 5th move] **4. Nd5z Bc5 5. Nf4z Bb4/Bd6/Be7/Bf8 6. Ne6 Bc5 7. Nd8! Bd4** (for 8. Nc6 Bc3) **8. Nb7! Bb6 9. Kc1!** and mate in 3 (**Ba5/Bc5 10. Nc5/Na5 Bd2+/Ba3+ 11. Kc2** and **12. Nb3#**).

Still within the realm of human ability, though stretching it to near its limits, is Troitzky's analysis of KNNKP. The Pawn is a liability, because the KNN side can sometimes immobilize the opposing King en route to checkmate without fear of stalemate. Usually the win, if possible, requires blocking the Pawn with one Knight and using the remaining K+N to slowly restrict the opposing King until the blocking Knight can release the Pawn to quickly complete the mating net. Since the Pawn and one Knight are usually inactive, this is closer to a three-man ending than a five-man one, but even so the analysis is remarkably difficult, and occupied Troitzky for many years. He was finally able to describe the winnable positions and how to play this ending; his results, confirmed many years later (with only minor corrections) by computer RA, underlie all subsequent KNNKP theory. The winning procedure can take well over 50 moves[3]. It would take us too far afield to exhibit such a line from beginning to end, but Diagram 3 gives some idea of what is involved.

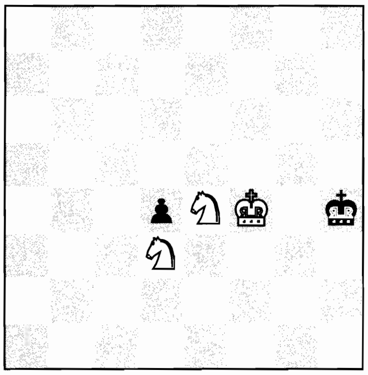

Diagram 3: Bridier (1952), wtm and win.

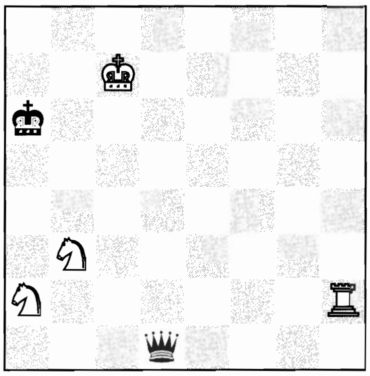

Diagram 4: Thompson (2000), wtm and win.

We join the analysis (Bridier, 1952) of the position wKh8Nc5Na7/bKd8Pd4 (reproduced in (Hooper and Whyld, 1984)) at move 76; since 1. Nd3, only the two Kings and the other Knight have moved, and the black King has been chased around the board from d8 to e4 to a2 to f8 to a4 to c8 to g7. It will finally perish on h1, but only after White's Knights have switched roles: **76. Ng3 Kh3 77. Nf5 Kg2 78. Kg4 Kf1 79. Ng3+ Kg2 80. Ne4 Kf1 81. Kf3 Kg1 82. Nd2 Kh2 83. Nf4! Kh1 84. Kg3 d3 85. Nf3 d2 86. Nd3! d1=N** (yes, there is an underpromotion here as well) **87. Kh3** and **88. N(×)f2#**.

3. COMPUTER RA AND EGTs

Going beyond Troitzky required computer power. Early work on KQK, KRK and KPK naturally did not change their evaluations, but already could produce data such as longest win and the number of wins in *n* moves that could not be reliably obtained by human-only analysis. Each added man multiplies the total number of possible positions by 64 (with some adjustment factors for repeated pieces, Bishops, and/or Pawns), and RA requires a randomly accessible index of all those positions. Advancing computer technology has taken about a decade to provide enough memory to accommodate an extra man. Four-man RA still did not substantially challenge the judgement of the best human analysts, though Ken Thompson's investigation of KQKR revealed so many new defensive resources that masters had to relearn how to win KQKR against best defence. But once five-man RA became possible, the results began to rewrite endgame theory, and the process continues as computer RA reaches six men and beyond and the Web makes it ever easier to disseminate and access RA results.

Pawnless endings were the first to be studied: a Pawn roughly quadruples the task because complete RA involves all four possible promotions. In some cases human judgement was largely vindicated, as with KRBKR, a notoriously difficult ending to defend — it is drawn in general, but there are many traps, and some positions can be won but take more than 50 moves with best play. In other cases, longstanding endgame theory was upended, notably for the ending KBBKN: this was long considered drawn if the K+N are not under immediate pressure, but RA (done by Thompson and Ofer Comay, working independently) proved it a general win often requiring more than 50 moves. The story was repeated as Thompson analysed more endings, including 5-man

[3] thus demonstrating that chess' 50-move law put some attainable wins theoretically beyond reach.

endings with one Pawn. In some cases, such as Troitzky's KNNKP, human analysis proved correct both in overall result and in most particulars; in others, such as KRPKR, the general shape of the boundary between won and drawn position remained, but many new possibilities appeared around the edges; and in yet other cases, particularly KQPKQ, entirely new resources emerged.

Ken Thompson organized his RA results into EGTs and distributed them in CD-ROM format. As this data became more widely available, human endgame experts were sometimes able to pinpoint where earlier analysts went wrong and how the ending should be played. John Roycroft started this process with KBBKN and KQPKQ, and John Nunn worked on many of these endings and collected his findings in his "Secrets of ... Endings" trilogy (Nunn, 1992, 1994, 1995). But some 5-man endings remain mysterious. No human can reliably tell whether a given KQKNN position is won or drawn with best play or estimate how many moves a given won position requires, and despite Roycroft's efforts the same is likely true of KQPKQ.

Meanwhile Lewis Stiller pioneered the RA of six-man endings. He obtained stunning results (Stiller, 1996): KRBKNN is a general win that can take 223 moves with best play; KRNKNN, though not generally won, contains a 243-move win; several other endings take over 100 moves; and most have a large number of mutual zugzwangs, many of which are very hard to understand. But there were tantalizing gaps, largely due to the fact that Stiller's research was at the edge of what technology then made possible: it was not possible to extract optimal-play lines unless the endgame had a repeated piece, or to save any EGTs for later study.

These obstacles no longer existed when Ken Thompson again took up RA a few years ago. He confirmed all of Stiller's results, filled in the gaps, and again disseminated his results, this time in a form accessible by Web query. He also analysed endings that Stiller passed up as uninteresting; while none of these contained anything as striking as "White to win in 200+ moves", some remarkable morsels turned up even in unpromising endings.

For instance, it is no surprise that KQRKRB is usually won, and quickly; but it is noteworthy that this ending contains a mutual zugzwang, and indeed a unique one: wKc6Qc2Ra2/bKb8Rc1Ba3. A human might have found this position — and it is easily, if not quite trivially, verified after the fact — but no human analysis could establish its uniqueness. Diagram 4 provides another example.

This is the longest win in KRNNKQ[4] (Elkies, 2000). Normally this ending is a draw: though the KRNN side is stronger, the Queen easily filibusters with checks and/or threats to capture the Rook, even at its own expense to reach the KNNK draw. Still, human analysts discovered many interesting winning possibilities when the KQ are poorly placed. Here Black soon hangs by a thread but it takes rather refined play to sever his lifeline.

An initial forcing sequence confines the black King to the corner: **1. Nc5+ Ka5** (Ka7? 2. Rh3/Nb4 with decisive mate threats) **2. Nb7+ Ka6 3. Nc3 Qa1 4. Nc5+ Ka7 5. Nb5+ Ka8 6. Nd4** interrupting the long diagonal to threaten 7. Rh8+ Ka7 8. Nc6#/Nb5#. Black must check, since 6. ... Q×d4? 7. Ra2+ mates and 6. ... Ka7? 7. Nc6+ Ka8 8. Nd7 is little better. 6. ... Qa5+?! is stronger, but still hastens the end by a dozen moves, e.g.: 7. Kc6 Qa7 8. Nde6 Qa1 9. Rh4 Qc3 (Ka7 10. Rh7+ and Black gets checked to death) 10. Rf4 with the point that after Kb8 11. Rf8+ Ka7 12. Nc7 there are no good checks (Qf6+/3+?) to stop 13. Nb5# or 13. Ra8#. Black's remaining defence lasts much longer: **6. ... Qa7+ 7. Kc6 Qb8** (Qg7 8. Nde6 etc.) **8. Ra2+ Qa7 9. Rf2 Qe7** (Qb8/Qg7? 10. Nde6 or 9. ... Qa5? 10. Rf3/1/Rg2 win quickly) **10. Nde6 Kb8** (Qe8+ 11. Kd6) **11. Rh2 Qe8+ 12. Kb6 Qg8**. Not yet Kc8? 13. Rh7. Now Black is limited to shuffling the King between b8 and c8 (Qe8? allows Rh7). If Black now had to move, then the forced ...Kc8 would let White progress with Kc6 (note that Rh2 stops ...Qg2+). So White transfers the move to Black by 'triangulating' on the h-file: **13. Rh4/1/3 Kc8** (Ka8? 14. Ra4+/1+/3+ Kb8 15. Nd7+ and 16. Ra8+; this is why White avoided 13. Rh5/6?) **14. Rh5/1/3/4/6 Kb8 15. Rh2 Kc8** (mission accomplished) **16. Kc6 Qe8+ 17. Kd6 Qg8** (Kb8? 18. Nd7+) **18. Rh3 Qe8 19. Rh4! Qg8** (or 19. ... Kb8? 20. Nd7+ Kc8 21. Rc4+ Kb7 22. Rb4+ Ka6 (Ka7 23. Ra4+ Kb7 24. Nec5+ Kc8 25. Ra8#) 23. Nc7+ Ka5 24. Rb5+ Ka4 25. Nc5+/Nb6+ and 26. N×e8) **20. Ke7! Kb8** (now forced, Qg~ 21. Rh8+ and mate) **21. Nd7+ Kc8 22. Rc4+ Kb7 23. Rb4+ Ka7/8**. 23. ... Kc6 24. Rb6+ Kd5 25. Nf6+, while 23. ... Ka6 24. Nb8+ Ka5/7 25. Nc6+ explains 19. Rh4! as opposed to Rh1/2. **24. Ra4+ Kb7 25. Nd8+ Kc7/8 26. Ra7/8+** and White wins in a few further moves, choosing between immediate checkmate, **26. ... Kc7 27. Ra7+ Kc8 28. Nb6+ Kb8 29. Rb7#/Nc6#**, and win of the Queen, **27. Ne6+**.

While Ken Thompson has for now left RA, others continue; recent work includes distance-to-mate EGTs (the current record length of 262 is again held by Stiller's KRNKNN position) and two 6-man endings with Pawns.

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[4] More precisely, one of the two longest wins. The other differs only in the first move: 1.Na4-c5+ instead of 1.Nb3-c5+.

Still, all these discoveries have had remarkably little effect on the way the game is played. While many of the computed endings occur often in practice, only rarely does a position arise where the computer has overturned the evaluation of human analysts. This is largely explained by the role of Pawns. In the starting position, every other man is a Pawn; then when only five or six men remain, usually several of them are Pawns. While promotions make Pawns inconvenient for complete RA, humans understand pawn endings much better than piece endings with the same number of men. The main objective is promotion, and once promotion is safely attained the resulting position can usually be evaluated intuitively. Until promotion, the Pawn has very limited scope, making analysis much more manageable. It is true that there are some endings such as KQPKQ or KQKRP that are significantly affected by RA and arise in practice on occasion; but there the RA results are very hard for most chess players to understand, and the effort needed to learn these endings would be out of any reasonable proportion to their frequency.

But RA has greatly affected another realm, that of chess composition, particularly studies. Perhaps some words of introduction to this realm are appropriate.

4. CHESS COMPOSITION

Most chess players have seen some chess compositions — diagrams captioned “White to play and win/draw” or “Mate in *n* moves” that did not arise in actual play but were constructed to illustrate some useful or surprising tactic. But relatively few Western chess players appreciate chess composition as an art. This art originates no later than the earliest surviving chess treatises, which already contain composed positions that make an instructive point in a purer form than could be found in most actual games. The terms *problem* and *study* (defined below) attest to the origins of chess composition in brainteasers and didactic positions. But the construction of such positions is itself a creative act, and soon became an aspect of chess pursued and enjoyed for its own sake. Chess composition now has a variety of artistic genres, schools and styles; a canon of classic masterpieces; many books and several periodicals devoted to the art; and scores of competitions each year, including world championships and titles for both composition and solving.

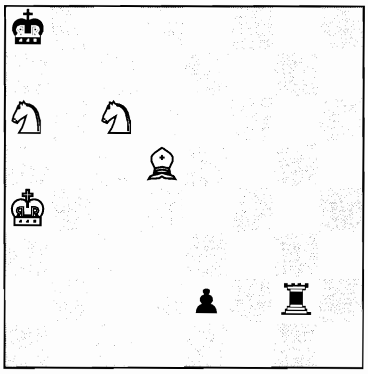

Diagram 5: Kipping (1911), wtm, mate in 3.

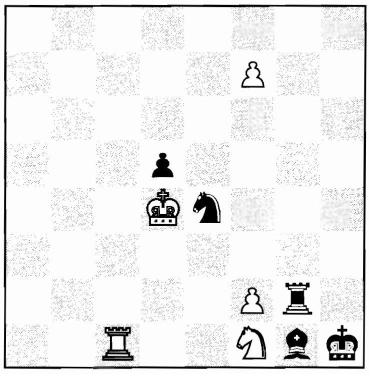

Diagram 6: Avni (1978), wtm and win.

Chess compositions are either *problems* which prescribe a number of moves to reach the goal (a typical stipulation is “White to Play and Mate in Three Moves”), or *studies*, where the number of moves is unrestricted and one need not analyse out to mate, only reach a clearly won or drawn position (for instance “White to Play and Win”)[5].

A couple of examples follow. For problems, Diagram 5 is an economical specimen (Kipping, 1911) whose solution can still surprise us after 90 years. White must involve his King in the attack before firing the Bd5-Nc6 battery. White can win with 1. Kb5(?), threatening 2. Ne7+ Ka7 3. Nc8#, which works also after 1. ... Kb7. If 1. ... Rg5 then 2. Kb6! mates next: the only defence to the threatened 3. Nc7# is 2. ... Rg7, but then 3. Ne7! mates anyway by exposing check from Bd5 and simultaneously blocking 3. ... Rb7. Black can try to delay the mate with 1. ... Rg6 (2. Ne7+ Rc6 and mate comes only on move 4), but 2. Kb6!, now a self-pin of the Nc6, still forces mate next in the same way (2. ... R×c6+ 3. B×c6#). So, what is wrong with 1. Kb5? Black can hold on for an extra move with 1. ... Rg8! (covering the intended mating square c8) 2. Kb6 Rc8!, and any discovered check allows 3. ... Rc6+. White still mates with 4. B×c6# but not as quickly as demanded.

[5] The convention is that the stipulation is expressed as a task for White wherever possible.

The solution is **1. Ka5!!**, keeping b5 open to add the threat 2. Nd4+ Ka7 3. Nb5# to 2. Ne7+ Ka7 3. Nc8#, and thus voiding the 1. ... Rg8 defence. The replies 1. ... Rg6/5 still defend, but are met with 2. Kb6! as before. But does not 1. Ka5 have the catastrophic drawback of allowing the new defence **1. ... e1Q+**? Well, Black can make a Queen with check, but White miraculously triumphs: **2. Kb6** still ensues, and we see that Kipping cleverly contrived the position so that each of Black's new defences to 3. Nc7# meets a new discovered checkmate. Observe: 2. ... Qa5+ 3. N×a5#, 2. ... Qb1+/4+/Rb2+ 3. Nc(×)b4#, 2. ... Qe3+/Qf2+/Qg1+ 3. Nd4#, 2. ... Qe5 3. N×e5#, 2. ... Qe7 3. N×e7#.

For an example of a study, let us turn to a creation by the Israeli master, author (Avni, 1998a, 1998b) and composer Amatziah Avni. Unlike the Kipping problem, the next position (Diagram 6) is far from the composer's best-known effort but it deserves wider recognition. This study (Avni, 1978) will also help us illustrate some of our subsequent concerns.

Naturally the first move is **1. f8=Q**, but after **1. ... R×f2**, the new Queen cannot hide from discovered check from the Bg1-Rf2 battery. It seems natural to go after the Rg1 with White's own battery Rc1-Nf1:

2. Ng3+!?, winning after 2. ... Kh2 3. Qh6+ or 2. ... Kg2 3. R×g1+ K×g1 4. Qb8!

But Black instead plays 2. ... N×g3! (now also threatening the fork 3. ... Ne2+), with the point that if 3. Q×f2 (the pinned Bg1 may not recapture) 3. ... Nf1!! when White can save his pinned Queen only by reviving his own pin with 4. R×f1 — but that is stalemate! The right way is **2. Qh6+! Rh2+ 3. Qe3!!**, a remarkable self-pin: Black is welcome to capture the Queen with 3. ... B×e3+ because then 4. N×e3 is discovered check and mate. Meanwhile White plans to extricate the pinned Queen with 4. Ng3+. So, **3. ... Rh3!** (or Rg2 with the same effect; 3. ... Kg2 4. Rc2+ K×f1 5. Rc1+ and 3. ... Rh4 4. Ng3+ N×g3+ 5. Kd3 are no better) but White still plays **4. Ng3+** because **4. ... R×g3 5. R×g1+ R×g1 6. Qh3** is **mate!**

As in any art form, aesthetic aims and judgements vary widely by genre and composer, but some standards are held almost universally; economy and soundness are particularly significant here[6]. Of these two, economy is the more familiar, being a goal of artists in any medium. In chess composition, economy means that every aspect of the problem or study should bear its full weight: ideally, each piece should play an active role, each move and variation should contribute to the overall effect, and the entire board should be used. In practice it is rare that a composer can fully attain this ideal, but compositions that flout it suffer noticeably: a profusion of passive pieces distracts us, a long and extraneous side-variation taxes our patience, and play limited to a few squares of the board usually disappoints.

The Kipping problem scores very high in economy: there are only seven men on the board, each of which moves at least once in some line of play; all lines contribute to either the logical distinction between 1. Kb5? and 1. Ka5!! or the remarkable position after 2. Kb6; and the board is fully used, with the Rook and Queen roaming every corner and the Nc6 discovering check or giving checkmate on seven different squares. The Avni study is concerned less with economy than with a variety of spectacular tactical effects, including several battery motifs, the stalemate defence 3. ... Nf1!, the self-pin 3. Qe3, and sacrifice of each of White's pieces in turn culminating with Black's choice of mate with a self-blocking Rook (on h2 or g1). Even so, Avni shows economy by compressing all this into six moves and a couple of variations, and thematic involvement by all men except the Pawns on f2 (there only to be captured on Black's first turn) and d5 (serving only to support the Ne4).

Soundness is a standard more particular to chess composition, at least in its absolute primacy: however brilliantly conceived, a problem or study loses its artistic value if it is ever proved unsound. For a composition to be sound, the intended solution (or solutions, in the case of several related routes to the goal) must be unique: an extraordinary idea loses its point if an alternative, usually much more ordinary, approach reaches the same goal. In problems where the opponent has multiple defences, at least the "thematic" line(s), containing the artistic core of the problem, are required to be free of unintended alternatives.

It is no surprise, then, that the computer has greatly affected chess composition by revolutionizing soundness testing. But this is not much different from using a strong computer program to assist us in analyzing openings or annotating games. On the other hand, the quest for economy has given RA and EGTs a role in chess composition, particularly study composition, much greater than any effect RA has had on the competitive game of chess.

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[6] For more about chess aesthetics, see (Levitt and Friedgood, 1995).

5. ENTER THE COMPUTER

The ideal of economy leads study composers to seek presentations of our ideas with as few pieces as possible; the quest for the extraordinary and piquant often leads us to positions with an unusual balance of force, near the boundary between won and drawn positions. Thus we are naturally drawn to the realm of positions with few enough men to allow evaluation by RA, and delicately balanced enough that this evaluation might contradict human expectations. For instance, of the 1258 studies in the classic collection of Sutherland and Lommer (1968), hundreds begin with no more than six men on the board, and hundreds more depend crucially on the outcome of variations where captures reduce the number of men to six.

Modern studies are similarly vulnerable. For example, for Avni's position in Diagram 6 to be sound, White's prosaic alternative 2. Q×f2 must give only a draw. In the resulting position, White has the advantage of Rook for Bishop, but with no Pawns this is not enough to win according to traditional theory. Still White can capture Black's last Pawn, entering six-man territory where RA often upsets traditional theory: with KRNKBN, there are many positions that are won but incomprehensibly so, with best-play lines lasting as long as 190 moves. Does 2. Q×f2 lead to such a win?

As it turns out, Avni's study does survive, though Black's drawing task is harder than one might expect; for instance, 2. Q×f2 B×f2+ 3. K×d5 Ng5! and now 4. Ne3+ Kh2! or 4. Rb1 Kg1/2! draws, but not 4. Ne3+ Bg1? or 4. Rb1 Nh3? when White wins in 67 or 81 moves respectively according to Thompson's website. But other studies have not fared so well. A number of studies in Sutherland and Lommer (1968) succumb to Thompson's CD-ROM or Web data. Modern studies are no more secure. For instance, Lewis Stiller recently searched through Van der Heijden's database of almost 60,000 studies, and announced by e-mail 305 "cooks", demonstrations of unsoundness, depending on the KRNKNN EGT alone.

But the EGTs can be constructive as well as destructive: composers can use them in the creation of new, sound studies. If a variation leads to a position in the EGTs, the composer can verify that it has the desired outcome, and if not then the composer may be able to adjust the study to eliminate the cook. Better yet, if the study is so economical that the initial position is in an EGT, then that EGT can certify the soundness of the entire study.

We can go even further, using the EGTs not only as a technical resource but also as a creative one. For example, Diagram 4 and its analysis emerged from Thompson's RA of KRNNKQ as a ready-made study which is both sound — White's winning move is unique at each stage that matters — and aesthetically at least comparable with the best of many human efforts with this material. Once an EGT is complete, it can be "data-mined" for positions that may have a strong enough aesthetic content to constitute endgame studies. Sometimes this recovers a known position, but often a new and surprising study emerges, one certified sound by the EGT. Nunn (1992, 1994, 1995) gives many such studies. Alternatively, the composer may provide introductory play including captures and/or promotions to create a study that is not yet fully RA-certifiable but reaches a remarkable position found in the EGTs. See for instance (Elkies, 1994) and (Van der Heijden, 2001) for studies where White deploys an RA-discovered zugzwang or underpromotion against two black Queens.

6. THE REACTION

These developments promise many new studies that could not have been created before the computer age. But some composers view this promise not with enthusiasm but with alarm, and have gone so far as to propose an antidote (Roycroft, 2000): studies contained in an EGT, whether actually extracted from the EGT or found independently, would be ineligible to win any tourney award; and if the study is not yet in an EGT, but part of its solution (after captures and/or promotions) is, then the composer should be credited only with the pre-EGT play. This rule would, we are told, spare tourney judges from comparing EGT-assisted studies with traditionally composed ones, and level the playing field between composers with and without access to the EGT data.

But this prescription is more problematic than has been generally appreciated: its premises are questionable, and its implementation would hurt the art of study composition, to an extent that will grow as increasing computer power brings more and more positions within reach of RA. I thank Harold Van der Heijden (2001) for suggesting a few of these problems: even within traditionally composed studies, there is great variety in methods, styles, and genres that judges must contend with, so the addition of EGTs presents no fundamentally new difficulty; and the playing field has never been level — composers have varying access to the study literature and to strong players to test their compositions, and have never before been penalized for bringing more resources to the art.

To this may be added that it is easy for an outsider to underestimate the effort and creativity required to construct and data-mine an EGT; the work and thought that went into the Thompson and Stiller databases, and into the studies in Nunn's trilogy, is no less than what a traditional composer usually applies to the creation of a study. But I believe that even more fundamental issues are at stake here.

First, while EGT data may feel alien to a human composer or enthusiast of studies, we have seen that RA is also one basic mode of human chess analysis. Computer-assisted RA, such as produced Diagram 4, differs only in extent but not in kind from the human RA that produced Diagrams 2 and 3 or even Diagram 1. As in chess annotation, and for that matter many fields outside chess, the computer is not our enemy but our tool and servant, extending our abilities for our use. Secondly, a ban on 'EGT' studies, when EGTs span ever more complicated positions, would compromise the principle of economy. It would already be impossible to win a prize for a study with five men or fewer; many six-man studies would also be taboo, and within a generation all seven-man positions would be beyond the pale. Composers often toil to eliminate any extraneous pieces and Pawns from our studies. Only rarely do we attain a setting in which every man plays a thematic part in the solution, an achievement appreciated by both solvers and judges. But now such complete success would paradoxically run counter to the regime of Roycroft (2000) and lead to disqualification. Composers who aim to win tourney awards will thus not work as hard to achieve economy, and might even submit an intentionally uneconomical position, including an unneeded man just to avoid the reach of EGTs. This may be a small effect nowadays, but as EGTs creep up to six men, seven men and beyond, economy would increasingly suffer. To be sure, not every study composer aims to win awards, but most do, and when prize-winning studies show less and less concern for economy, the art as a whole will inevitably be affected.

7. THE COMPUTER AND CHESS PROBLEMS

A comparison with the world of chess problems may be illuminating. There too the computer has had a decisive impact, though in a different way. RA-assisted composition is still in its relative infancy, though occasionally one sees positions such as Walter's wKh2Ba3Nb1/bKd4 (Ebert[7], 1990), which the EGTs certify as a sound Mate in 31.[8] Most problems are far from the economy of Kipping's Mate in 3, Diagram 5, and even that position is still one Pawn away from EGT range. Where the computer most changed problems, though, is in soundness testing. Before the computer, problem composers worked very hard trying to ensure their problems' soundness, and even then solvers often found unintended solutions or unexpectedly strong defences. With the advent of fast solving programs, many more cooks emerged in classic problems; but others could be certified sound. (While the general position with more than six men is beyond the reach of RA, forward analysis can still decide whether it is a sound "Mate in *n*" for small *n* because there are relatively few possibilities to test.)

More importantly, computer testing has taken much of the cook-hunting drudgery out of chess composition. This has improved the quality and quantity of chess problems in several ways: without the distraction of cook-hunting, composers can concentrate on the creative process; since this makes composition more enjoyable, more people are spending more time doing it; and composers can take on more daring and difficult ideas that their predecessors would shun for fear of cooks. This has surely changed the face of problem composition: the computer makes possible new kinds of problems, and composers without access to a solving program would be at a severe disadvantage. But the community of problemists responded, not with resentment or bans against problems composed with the aid of solving programs, or for that matter of RA, but by embracing the new technology.

Going back to studies, we see that RA and EGTs are exerting their effects more slowly and on a smaller segment of the art. This makes it feasible, at least for a while, to contemplate disqualifying RA-assisted composition. But feasibility does not make such a ban desirable, and as we have seen the benefits, if any, of a ban would be greatly exceeded by its costs.

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[7] where, van der Heijden notes, there is a diagram misprint: the 'wRb1' should be 'wNb1'.

[8] The solution starts 1 Kg3; while winning KBNK, though nontrivial, is well within human comprehension, verifying that such a Mate in 31 is sound is another matter.

8. CONCLUSION

The RA work of Ken Thompson and others has a particularly strong and growing impact on chess studies. This will be the case whether or not the proposal of Roycroft (2000) is adopted; the only difference is the nature of the resulting impact. I believe that this proposal is not well considered and will increasingly circumscribe and distort the art. Only by embracing the EGTs and the new studies that they make possible will we reap the full rewards of endgame RA.

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COMPUTER DISCOVERIES IN LOSING CHESS

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ABSTRACT

The history of Losing Chess endgame analysis by computer is outlined, and some particularly striking discoveries are quoted.

This paper briefly surveys computer activity in a game which may be unfamiliar to readers of the *ICGA Journal*. It shows, perhaps even more strikingly than the many Thompson-derived endgame studies in ordinary chess have shown, how the computer can help us by digging rapidly over vast tracts of ground and pointing out interesting positions.

Losing Chess (a player must take if he can, the object is to lose all one's men, the King is an ordinary man and can be captured) is one of the most widely played of all unorthodox forms of chess. It is usually played strictly for fun, but players have long realised that the endgame is full of subtlety. The game is over a hundred years old (Beasley (2000) gives references in print back to 1885) but not until Gyorgy Evseev's 1992 analysis of the ending N-NN did anyone enlist the services of a computer (Evseev and Poisson, 1993). Nothing more seems to have been done until my 1997 analysis of three-man pawnless endings (Beasley, 1999), but further analyses soon followed: by Laurent Bartholdi in 1998 of all three-man endings and in 1999 of R-KKK, and by "Angrim" (Ben Nye) in 1999 of all four-man endings. The primary purpose of Bartholdi and "Angrim" was to generate data for use by other programs and their results have not been made available in full, but a number of positions have appeared on the Internet[2] (Liardet, 1999) and subsequently in print (Beasley, 2000; Binnewirtz, 2000). The analysis is computationally similar to that of endgames in ordinary chess, so five-man data tables can now be computed using off-the-shelf personal computers and six-man tables using state-of-the-art equipment, but there is little incentive to do such calculations while even the four-man data remain imperfectly understood.

The actual computing was routine and not of interest, and the rest of the paper will display some of the more striking positions disclosed. These were extracted from the data by the simplest of means, by examining (a) the longest wins with given combinations of material, (b) any positions which existed uniquely or in unusually small numbers (positions equivalent under reflection or rotation being treated as the same), and (c) positions in which having the move was a disadvantage (either because whoever had it would lose, or because a player could win more quickly without the move than with it). In what follows, " indicates a unique winning move (to within symmetry) and ' a unique optimal move, while ! is a subjective expression of approval. Only in the case of the three-man pawnless positions do I have access to the data tables, and signs " and ' elsewhere are based on *ad hoc* analysis using Stan Goldovski's program *Giveaway Wizard* (Goldovski, 1997).

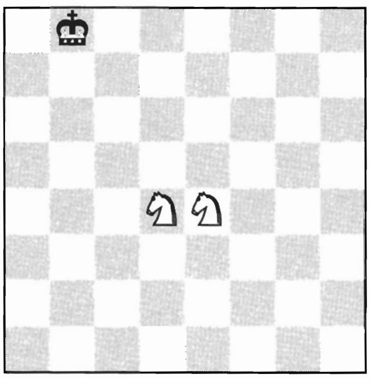

Diagram 1: White to move.

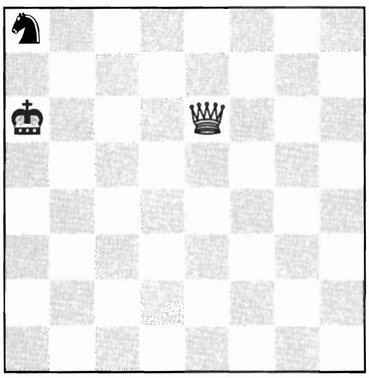

Diagram 2: Black to move.

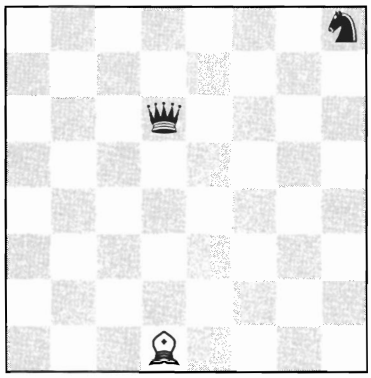

Diagram 3: White to move.

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[2] Probably the best current Internet gateway to Losing Chess material.

"Longest wins" tend to be deep rather than elegant, but sometimes they contain interesting tactical moments. White can win in **Diagram 1** only because the black King is already penned into the corner, and play proceeds **1. Nf6" Ka7'** (1. ... Ka8 2. Nd5" and Black's next move will allow two giveaways) **2. Nb5" Ka8' 3. Nc7"!** (the immediate giveaway 3. Na7 loses) **Ka7' 4. Na8'!** (4. Na6 is another losing giveaway, while 4. Nb5 wastes time) **K×a8 5. Nd5"** and the bK is dominated. It is a highly paradoxical manoeuvre: White attacks bK by 2. Nb5 and waits for him to move away, but then White *doesn't* give his Knight away on the square Black has just vacated but attacks him again by 3. Nc7! Similar play had already been shown in a problem by Stan Goldovski, White Nd4, Pd7 (2), Black Ka7 (1), win in five moves by **1. Nb5" Ka8' 2. Nc7"!** (2. Na7 only draws) **Ka7' 3. Na8'!** (3. Na6 K×a6 4. d8R" also wins, but not in five moves) **K×a8 4 d8B"** (Goldovski 1999, published posthumously), but the computer discovery is even neater.

The longest Q-KN win has Qg5 against Na8/Kb8, and after **1. Qh5'** (1. Qd2 also wins but takes longer) **Kb7' 2. Qd1'** (2. Qg5 also wins) **Kb6** (2. ... Ka7 leads to the same finish) **3. Qg4" Ka6** (3. ... Ka7 is as good, but the finish is less interesting) **4. Qe6** (4. Qg6 is as good) we have **Diagram 2**. White to move would now lose at once, but Black must "improve" his position to his disadvantage: 4. ... Nc7 defends his King, 4. ... Nb6 shields it, 4. ... Kb6 moves it to a defended square, and any other move takes it out of range of White's attack.

Diagram 3 is a remarkable position: the solitary draw with this material! My immediate reaction to a draw count of "1" was that there had to be a program error, because a draw must cycle through at least two different positions. But when we examine the play we find **1. Ba4'!** (only safe move) **Qf4'!** (only safe reply) and we have a reflection of the starting position.

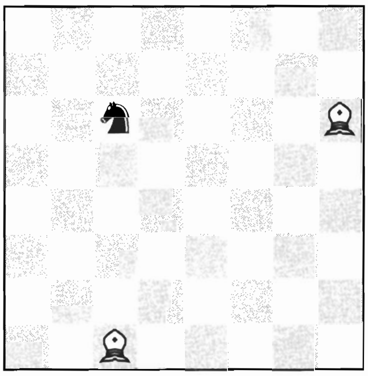

Diagram 4: Whoever moves loses.

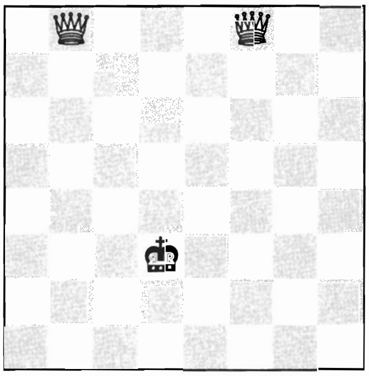

Diagram 5: Whoever moves loses.

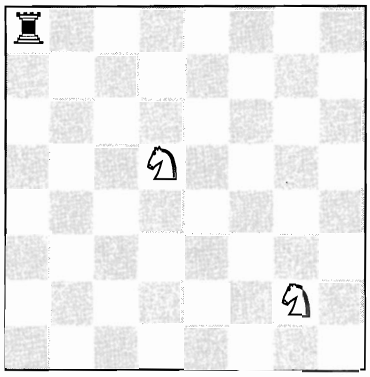

Diagram 6: White to move.

Diagrams 4 and 5 show two of the more amusing positions of reciprocal zugzwang. Remove Bh6 in **Diagram 4**, and White could win by 1. Bc1-h6"; give him a second Bishop already on this square, and he has no good move. Similarly, if he had only a single Queen in **Diagram 5** he could win by playing 1. Qb8-f8" or 1. Qf8-b8"; give him both, and he is lost.

But the most surprising three-man computer discovery is **Diagram 6**. With Black to play, White has only 22 non-trivial wins with this material, but the longest takes 12 moves and something remarkable must be going on. In fact the wins depend on two positions of domination: Diagram 6 but with Black to move, when any black move allows two immediate giveaways, and the same position with the Knights on g5/d2. But it is White to move, and he must tread very carefully if he is to reach one of these positions. Play starts **1. Ngf4"** (1. Nge3 is equivalent by symmetry) **Ra1' 2. Ng6" Ra2' 3. Ne5"** and Black has three plausible moves. 3. ... Rh2 loses to 4. Nb6" Rh1' 5. Nc4' (5. Nd7/Nd5 lose time) Rh8' 6. Nb2' (6. Nd2 loses time) and the rook is dominated (we have Diagram 6 reflected right to left and with Black to move). If 3. ... Ra1 then 4. Nf6" Ra2' (4. ... Rb1 is equivalent by symmetry) 5. Nfd7' (5. Nd5 loses time) Rh2' (if 5. ... Ra1 then 6. Ng4' with the second position of domination) 6. Nb6" and we have the same position as after 3. ... Rh2 4. Nb6. This leaves **3. ... Ra8"**, when White must play **4. Ng4" Ra1' 5. Ngf6'** (5. Ne5 loses time) **Ra2' 6. Ng8"!** (remarkably, this is the only way to win) **Ra1' 7. Nge7'** (7. Nf6 loses time) **Ra2'** (7. ... Rh1 8. Nb4' dominating) **8. Ng6'** (8. Ng8 loses time) **Ra1' 9. Ngf4'** (9. Ne7/Ne5 lose time) **Ra8' 10. Ng2'** (10. Ne2 loses time) and we are back at Diagram 6 but with Black to move. *Moving only a Knight, White has contrived to transfer the move to his opponent.*

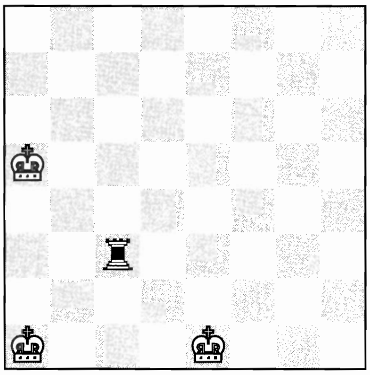

Diagram 7: whoever moves loses.

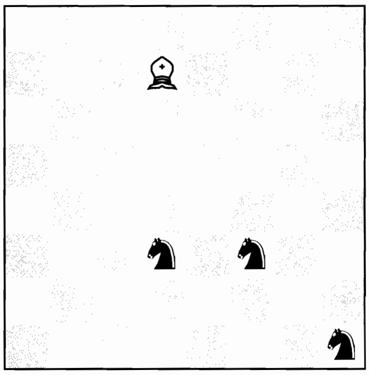

Diagram 8: only a draw.

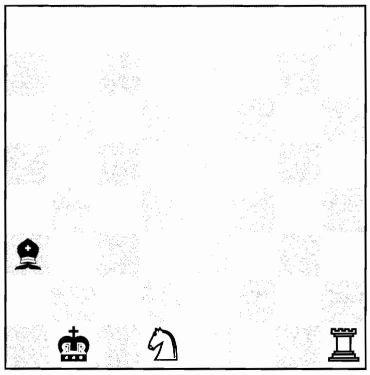

Diagram 9: whoever moves loses.

The most frequent promotions in practical play are to Rook and King, and R-KKK was the first four-man computer-analysed ending. In general, it is a win for the Kings, which group themselves and then advance, eventually reaching a position of domination such as Kb4/Kd2/Kf6 v Rh8. In **Diagram 7**, Black to move will have to allow just this. White to move, 1. Kb5/Kb6 Rc5 obviously, but why not **1. Kf1 Rd3"** (everything else can be shown to lose) and now 2 Kb5/Kb6? Because Black has 2. ... Ra3"! White can no longer give away all three Kings; instead, Black will now capture wKa1 and one other King, leaving himself with a winning R v K ending. So White has only **2. Ka6** (or 2. Kg1, when 2. ... Re3" will put him back in the same dilemma) and the stately dance continues: **2. ... Rd4" 3. Kg1 Re4" 4. Ka7** (or 4. Kh1 Rf4" etc) **Re5" 5. Kh1 Rf5" 6. Ka8 Rf6"** and White has run out of moves. In Fabrice Liardet's delightful phrase, "the Kings get quartered".

B-NNN is normally a win for the Bishop, but "Angrim" found six fortress positions for the Knights. **Diagram 8** shows one of them. The point is that if White attacks any Knight, Black can give away two Knights and then set up one of the two exceptional winning positions with N v B: for example, 1. Bc6 Ng3" 2. B×f3 Nh5" 3.B×h5 Nc5" and wB is dominated, or 1. Bb5 Ng3" 2. B×d3 Nf1" 3. B×f1 Nh2" and wB must move away and allow the black Knight to sacrifice itself. So White must play a non-attacking move, say **1. Be6**, but each such move allows Black a safe reply (for example, 1. Be6 can be met by **1. ... Nfe1'**) and he will restore the fortress position next move.

If Diagrams 4 and 5 showed two of the more amusing computer-discovered positions of reciprocal zugzwang, **Diagram 9** shows one of the most remarkable. Black to play obviously loses (if 1. ... Ka1 then 2. Nb2' and 2. ... B×b2 now fails because it defends bK), but why cannot White to play simply wait by **1. Rg1**? Because of what Fabrice Liardet calls "one of the most amazing moves I have ever seen": **1. ... Bc5"!!** The only reply to offer any hope is **2. Nb2**, and after **2. ... B×g1** where is the wN to go? It cannot give itself away, and any move by it will allow Black to play **3. ... Kb2** and then win with B-N.

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[3] JDB material available from the British Library and the chess collections at Cleveland, The Hague and Melbourne.
[4] Pages apparently reconstructed by his friends in his memory following his untimely death.

KING AND TWO GENERALISED KNIGHTS AGAINST KING

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ABSTRACT

A Knight jumps two squares in one direction and one square in the other. It can be generalised as a *Leaper* which jumps *x* squares in one direction and *y* squares in the other. At various times in its history, chess has featured other pieces of this kind, in particular, the mediaeval *Firzan* which moved one square in each direction. Calculations are described which examine the general outcome of the ending "King and two Leapers against King" on a square chessboard of any size. In particular, it is shown that all endings of this kind appear to be drawn on boards larger than 13×13, and that two identical Leapers cannot mate from a general position.

Every practical chess player knows that two Knights are insufficient to force mate against a lone King. But a Knight is merely a particular example of a piece known in generalised forms of chess as an *(x,y) Leaper* which jumps *x* squares in one direction and *y* in the other, and ever since my youth the question has been running through my head as to whether there might exist two (x,y) Leapers, not necessarily the same, which could combine with their King to force mate against a bare enemy King from a general position.

The advent of personal computers, and their continually increasing memory capacity, has enabled me to write a program which appears to give a complete answer to this question. The first part of the analysis (Kotěšovec, 1994, 1996) considered boards up to 8×8, and showed that on an 8×8 board there were seven and only seven combinations of two Leapers which could combine with their King to force a win from a general position: (0,1) and (1,2), or one of (0,1)/(1,2) and any one of (1,3)/(1,4)/(1,6). The results were reported in the English-language chess press (Whyld, 1994; Beasley, 1996) and independently confirmed by Smith (1995) and Stewart (Gent, 1996). The second part of the analysis (Kotěšovec, 2000; Beasley, 2001) identifies the winning combinations on boards up to 13×13, and shows with virtual certainty that all endings of this kind are drawn on larger boards. The analysis also shows that no two identical Leapers can mate from a general position.

Table 1 summarises the results. It lists the longest wins in all endings which are won from a general position. Excluded are positions which cannot be reached in play (for example, a (1,6) Leaper on an 8×8 board cannot play to d4) and positions where the lone King can force the capture of one of the Leapers (for example, white Knight on a1, black King on b2, no white man guarding c2 or b3). There are also some interesting drawn positions which might provide ideas for endgame studies, for example white King K on e5, Knight N on b1, (1,3) Leaper X[2] on a1, black King on b3, play **1. Nd2+ Kb2! 2. Xb4 Kc3! 3. Xa1 Kb2! 4. Xb4** and a draw by repetition. But with these exceptions a win is always possible within at most the given number of moves (for example, given a King on a2 and Leapers on a1/b1 against a King on any legal square away from the edge, the enemy King can be pressed back into a corner of the board and there mated).

Some additional endings can be won provided that the enemy King is already penned into a corner of the board. For example, with white K on c3, (1,1) Leaper F on b2, (3,4) Leaper A on g1, black K on a2, there is a mate in 12 by **1. Ac4 Kb1 2. Af8 Ka2 3. Ab5 4. Ae1 5. Ah5 6. Ad2 7. Aa6 8. Ae3 9. Ah7 10. Ad4 11. Aa8/Ah1 Kb1 12. Ae5** (Kotěšovec, 1984). However, there is no win from a general position with this material.

The 1994 analysis generated the first five columns of Table 1, and showed in particular that there were seven generally winning combinations on an 8×8 board. The more recent analysis shows that each of these endings becomes drawn once the board exceeds a certain size. The problem lies in penning the enemy King into a corner. On a larger board the lone King has more room to manoeuvre and can keep the superior side at bay.

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[2] Generalised Knights featuring here: *Wazir* W (0,1), *Firzan* F (1,1), *Knight* N (1,2), *Camel* X (1,3), *Giraffe* G (1,4), *Flamingo* Y (1,6), *Antelope* A (3,4).

Leapers \ Board	**4×4**	**5×5**	**6×6**	**7×7**	**8×8**	**9×9**	**10×10**	**11×11**	**12×12**	**13×13**	**14×14**	**15×15**
# of Leaper-pairs	45	105	210	378	630	990	1485	2145	3003	4095	5460	7140
(0,1) + (0,2)	31	19y	-	45y	-	-	-	-	-	-	-	-
(0,1) + (1,1)	15	18b	45	38b	-	94b	-	-	-	-	-	-
(0,1) + (1,2)	17	22	29	38	45	57	71	101	194	-	-	-
(0,1) + (1,3)	20	30b	40	40b	77	68b	-	-	-	-	-	-
(0,1) + (1,4)	x	38	37	45	55	82	-	-	-	-	-	-
(0,1) + (1,5)	x	x	58	50b	-	-	-	-	-	-	-	-
(0,1) + (1,6)	x	x	x	87	93	-	-	-	-	-	-	-
(0,1) + (2,4)	x	23b	65	43y	-	-	-	-	-	-	-	-
(0,2) + (1,2)	-	19y	55	45y	-	69y	-	-	-	-	-	-
(0,2) + (1,3)	-	21wy	-	44wy	-	67wy	-	-	-	-	-	-
(1,1) + (1,2)	17	19b	36	37b	-	56b	-	-	-	-	-	-
(1,1) + (2,3)	-	-	-	47b	-	82b	-	-	-	-	-	-
(1,1) + (2,4)	x	32z	-	-	-	-	-	-	-	-	-	-
(1,2) + (1,3)	21	21b	33	31b	49	45b	-	67b	-	119b	-	-
(1,2) + (1,4)	x	37	34	36	41	48	61	85	-	-	-	-
(1,2) + (1,5)	x	x	46	36b	-	54b	-	106b	-	-	-	-
(1,2) + (1,6)	x	x	x	48	53	62	78	143	-	-	-	-
(1,2) + (1,7)	x	x	x	x	-	77b	-	-	-	-	-	-
(1,2) + (1,8)	x	x	x	x	x	-	123	-	-	-	-	-
(1,2) + (2,4)	x	26b	60	33y	-	50y	-	-	-	-	-	-
(1,3) + (2,4)	x	35z	-	35wy	-	51wy	-	-	-	-	-	-

An ending is regarded as *won* if King on a2 and Leapers on a1/b1 can force a win against a King on any legal square away from the edge. The number gives the distance to mate in the least favourable winning case, including cases where King and Leapers start on other squares. Endings which are not won in this sense are denoted by "-", and which do not exist by *x*.

Endings marked *b* are won only if the Leaper for which $x+y$ is even runs on black squares, assuming that the board is always coloured so that square a1 is black.

Endings marked *y* are won only if the (0,2) or (2,4) Leaper runs on black squares and additionally is able to reach squares a1, c1 etc. In other cases the ending is drawn: for example, a (0,2) Leaper on b2 can never play to reach a1.

Endings marked *wy* are won only if condition *y* is satisfied and the (1,3) Leaper runs on white squares.

Endings marked *z* are won only if the (1,1) or (1,3) Leaper runs on white squares and the (2,4) Leaper runs on black.

Table 1. Winning endings with King and two Leapers against a bare King.

It is convenient to consider even and odd boards separately. Of the seven endings which are won on an 8×8 board, only three are still won on a 10×10, together with the combination (1,2)+(1,8) which does not exist on the smaller board. The only winning combination on a 12×12 board is (0,1)+(1,2), and even this is not winning on a 14×14. On a 12×12 board, the win with white King on a1, (0,1) Leaper on a12, and (1,2) Leaper on l1 against black King on j4 takes 194 moves! Coming to odd boards, of 15 winning endings on a 9×9 board only five remain winning on an 11×11, and only one, (1,2)+(1,3), on a 13×13. The win with white King on a1, (1,2) Leaper on l13, and (1,3) Leaper on m13 against black King on a3 takes 119 moves. The same combination on a 15×15 board is only drawn.

If an ending is only drawn on a board of side *n*, we can assume that it is also drawn for *n*+2, *n*+4, and so on. (There are two exceptions on small boards: (1,1)+(2,3) is won on a 7×7 board but only drawn on a 5×5 because the (2,3) Leaper has severely impaired mobility, and (0,2)+(1,2) is won on a 6×6 but only drawn on a 4×4 because the White men get in each other's way.) There remains the possibility that there may be wins for combinations which do not exist on smaller boards, as in the example (1,2)+(1,8) on the 10×10. However, in view of the limited powers of movement of such Leapers it is very unlikely that further endings of this kind are won; for example, (1,2)+(1,10) on the 12×12 is drawn. For boards up to 12×12 I have examined all possible combinations of Leapers, for larger boards only those which are won on smaller boards.

Thus it is possible to announce, almost with certainty, that all endings of this kind are drawn on boards larger than 13×13. The examples below show three of the longest maximal wins on the 8×8 board: ° indicates a unique legal move and ' a unique optimal move. In conclusion, one might ask what is the largest board on which a trio of Leapers can combine with their King to force mate against a bare King. Perhaps the resolution of this far from trivial problem will be a task for the next generation.

Example 1. Board 8×8, white K on d2, (0,1) Leaper W on h5, (1,6) Leaper Y on c8, black K on h3.

1. Wg5' Kh4' 2. Wg6 Kh5' 3. Wg7 Kh6' 4. Wf7' Kg6' 5. We7' Kf6' 6. Wd7' Ke6' 7. Wc7' Kd6' 8. Wb7' Kd7 9. Yb2' Kc6' 10. Wb8 Kc7' 11. Wa8' Kc6 12. Kc3 Kc5' 13. Yh1' Kd5' 14. Kb4 Kd6 15. Wa7 Kc6 16. Wa6 Kd5' 17. Wa5 Ke6 18. Kc5 Kf7 19. Kd5 Ke7' 20. Wb5 Kf6' 21. Ke4 Kf7 22. Ke5 Kg6' 23. Wb6 Kf7' 24. Wc6' Kg6' 25. Wd6' Kf7' 26. We6' Ke8' 27. Yg7 Kd7' 28. Kd5 Kc7' 29. Kc5' Kd7' 30. We5' Ke8' 31. Kc6 Ke7 32. Ya6' Kd8' 33. Yg5' Ke8 34. Kd5 Kf8 35. We6 Ke8 36. Ya4' Kf8 37. Yg3' Ke8 38. Ya2' Kf7' 39. Ke5' Ke8 40. Yg1' Kd7' 41. Kd5 Kc7' 42. Wd6' Kd8' 43. Ke6' Kc7' 44. Yh7' Kb7' 45. Kd7' Ka6' 46. Kc6' Ka5' 47. Kc5' Ka4' 48. Kc4' Ka3' 49. Wd5 Kb2' 50. Yb8' Kb1' 51. Kd4 Kc1' 52. Kd3' Kd1' 53. Ke3 Ke1' 54. Wd4' Kf1' 55. Wd3' Kg2' 56. Kf4' Kh3' 57. Yh7' Kg2' 58. Wd2' Kf1' 59. Yb8' Kf2' 60. Ya2' Kf1' 61. Kf3' Ke1' 62. Ke3' Kf1° 63. We2' Kg2' 64. Wf2+' Kh3' 65. Kf4' Kh4' 66. Kf5 Kh5' 67. Wf3 Kh6' 68. Kf6' Kh7 69. Wf4 Kh6' 70. Wg4' Kh5' 71. Kf5' Kh6° 72. Wg5' Kg7' 73. Ke6' Kf8' 74. Yb8' Ke8 75. Yc2' Kf8° 76. Wg6' Ke8' 77. Wg7 Kf8° 78. Wf7+' Ke8' 79. We7+' Kf8° 80. Kf6' Kg8° 81. Wf7 Kh7' 82. Kg5' Kg8' 83. Kg6' Kh8° 84. Yd8 Kg8° 85. Kf6 Kh8' 86. Kg5 Kh7' 87. Kh5' Kh8' 88. Kh6' Kg8° 89. Kg6' Kh8° 90. Ye2' Kg8° 91. Yf8' Kh8° 92. Yg2+' Kg8° 93. Wf8#'.

Example 2. Board 8×8, white K on a1, (0,1) Leaper W on g5, (1,3) Leaper X on h6, black K on f4.

1. Wg6' Kf5' 2. Wg7' Kf6' 3. Wg8' Kf7' 4. Wh8' Kg7 5. Xe7' Kf6' 6. Xf4' Kf5 7. Xc5' Kg6' 8. Xd8' Kf7 9. Ka2 Ke8 10. Xg7 Ke7 11. Kb3 Kf6' 12. Xd8 Ke7' 13. Xc5' Kf7' 14. Xf4' Ke6 15. Kc4 Kf5' 16. Xg7 Kf6 17. Xh4' Kg6 18. Kd5' Kh6 19. Ke5 Kg5 20. Xg7 Kg6 21. Xd6' Kf7' 22. Wh7' Ke8 23. Ke6 Kd8' 24. Wg7' Kc7' 25. Kd5' Kd8 26. Wf7' Ke8' 27. Ke6' Kd8° 28. Xc3' Kc7' 29. Kd5' Kd7' 30. Xf4 Kc7' 31. We7' Kb6' 32. Wd7' Kb5' 33. Wd6 Kb6 34. Wc6+' Ka7 35. Kd6 Kb7' 36. Wc7+ Kb6' 37. Xe7+' Ka5 38. Kd5 Ka6' 39. Kc5' Ka7' 40. Kc6' Ka8' 41. Wc8' Ka7° 42. Wb8' Ka6° 43. Wb7' Ka5° 44. Xf4' Kb4' 45. Kd5' Kb5' 46. Xg1' Ka5' 47. Kc5' Ka6' 48 .Kc6' Ka5° 49. Wb6' Kb4' 50. Kd5' Kc3' 51. Ke4' Kb4' 52. Kd4' Ka5' 53. Kc5' Ka4° 54. Xf4' Kb3' 55. Kd4' Kc2' 56. Ke3' Kb3' 57. Kd3' Kb4' 58. Kd4' Kb3' 59. Wb5' Kc2' 60. Ke3' Kd1' 61. Kd3 Kc1° 62. Wb4' Kd1' 63. Wb3' Kc1° 64. Ke2' Kc2' 65. Wb4' Kc1' 66. Xe7 Kc2' 67. Xd4 Kc3' 68. Xc1' Kb2 69. Kd2' Ka2' 70. Kc3 Kb1' 71. Xd4 Ka1' 72. Kb3' Kb1° 73. Wa4' Ka1° 74. Kc2' Ka2° 75. Xg3 Ka1° 76. Xd2+' Ka2° 77. Wa3#'.

Example 3. Board 8×8, white K on c2, (0,1) Leaper W on h3, (1,2) Leaper N on a8, black K on e1.

{First, the wK takes control of both Leapers} 1.Nc7' Kf2' 2.Ne8' Kg2' 3.Wh4' Kg3' 4.Wh5' Kg4' 5.Ng7' Kf4' 6.Kd3' Ke5' 7.Ne8' Kf5' 8.Wh6' Kg5' 9.Wh7' Kf5' 10.Ke3' Kg6' 11.Wg7+' Kf5' 12.Kd4' Ke6' 13.Kc5' Ke7' 14.Nd6' Kf6' 15.Wf7+' Ke6' 16.Kc6' Ke5' 17.We7' Kf6' 18.Nc8' Ke5 {Now White starts to press the bK into a corner} 19.Kc5' Ke4 20.We6' Kf5 21.Kd5' Kf4' 22.Kd4' Kf5' 23.We5+' Kg6 {23 unique optimal moves by White} 24.Ne7+ Kf6' 25.Nc6' Kg5' 26.Ke4' Kg4' 27.Wf5' Kg3' 28.Ke3' Kg4' 29.Ne7' Kg3 30.Wg5' Kh4' 31.Kf4' Kh3° 32.Kf3' Kh4' 33.Wg6' Kh5' 34.Kf4' Kh4° 35.Nf5+' Kh3' 36.Kf3' Kh2° 37.Kf2' Kh3 38.Wg5' Kh2° 39.Wg4 Kh3 40.Wg3+ Kh2° 41.Kf1 Kh1° 42.Nd6' Kh2° {forcing mate is now easy} 43.Ne4' Kh1° 44.Nf2+' Kh2° 45.Wg2# {or Wh3#}.

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NEWS, INFORMATION, TOURNAMENTS AND REPORTS

REPORT ON THE 11TH CSA WORLD COMPUTER-SHOGI CHAMPIONSHIP

Kazusa ARC, Kisarazu, Japan
March 10-12, 2001

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1. Introduction

After many CSA Championships hosted by the Sheraton Hotel, the 11th CSA World Computer-Shogi Championship took place in the Kazusa Academic Park in Kisarazu. This is a very impressive complex of the top class hotel Okura with a big conference centre for events. It is located just outside Tokyo.

In the 11th CSA tournament the magic number of 50 participants was exceeded. There were 55 programs ready for competition. For the first time, the tournament was called the World Computer-Shogi Championship. Of course, everyone already knew that the tournament had this status. As for the "World" part: this year there were exactly the same four non-Japanese participants as last year: Jeff Rollason's SHOTEST from England, Pauli Misikangas' SHOCKY from Finland, KCC SHOGI from North Korea and my program SPEAR from The Netherlands (even though I live in Japan for a long time). KCC SHOGI was the centre of attention. There was a camera crew of Japan's top news program from the Asahi television station, following both KCC SHOGI and IS SHOGI (the winner of last year), and hoping for a Japanese-Korean showdown in the finals. The North Koreans had come to the tournament with a big delegation. In previous years, there were only two Japanese operators, but this time the main programmers and some company officials had also made the trip to Kisarazu. Of course, they had first to pass the preliminary stages before having any prospect of the championship. Last year KCC SHOGI failed surprisingly.

The competitive procedure was almost the same as in last year's tournament. There were still three stages: eight programs would qualify from the first preliminary tournament to the second preliminary tournament. This second preliminary tournament would have 24 programs. Last year five programs from this second preliminary tournament qualified for the finals, with three programs seeded from the year before. In 2001 the finals were a tournament of 10 programs, so 7 programs would qualify for the finals from the second preliminary tournament. The time limits for each game were again 25 minutes (minimum 1 second per move) for all tournament stages.

2. The first preliminary stage

Last year, SPEAR easily qualified for the second round with six wins and only one loss. Still, I felt that it might be a little tougher this time. First, there would be no less than 36 entries, of which only 8 programs would qualify. Furthermore, there were two strong programs that re-entered the tournament after an absence of one or more years. YANO SHOGI was a former finalist and a program that was written completely in assembler code. It seemed that the time off had been used to rewrite the program in C. The second re-entry that was expected to do well was AMANO SHOGI. This program had never qualified for the finals, but had played many years in the second preliminary tournament. It would be a stable program and that is probably the most important thing in a CSA tournament.

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No	Program Name	1	2	3	4	5	6	7	Pts	SOS	SB
1	YANO SHOGI 4	16+	36+	5+	20+	4+	3=	6+	6.5	27.5	22.0
2	AMANO SHOGI	10+	29+	20+	4–	3+	5+	9+	6.0	29.5	24.5
3	HYPER SHOGI 7	22+	8+	11+	15+	2–	1=	4+	5.5	34.0	21.5
4	SPEAR	30+	14+	15+	2+	1–	9+	3–	5.0	32.5	20.5
5	OJIRO	18+	28+	1–	13+	26+	2–	14+	5.0	29.5	17.0
6	SUZU NO NE	12+	24+	23+	9–	13+	20+	1–	5.0	28.0	17.0
7	USAPYON	24+	12–	14–	22+	28+	27+	17+	5.0	23.0	15.0
8	TACOS	34+	3–	13–	30+	23+	22+	12+	5.0	23.0	13.5
9	S1.6	19+	11=	27+	6+	21+	4–	2–	4.5	30.0	14.5
10	ISOBE SHOGI	2–	15–	31+	25=	30+	24+	13+	4.5	24.0	11.0
11	FUKU SHOGI	25+	9=	3–	21–	19+	35+	20+	4.5	23.5	10.5
12	SHOKO	6–	7+	17+	14–	16+	15+	8–	4.0	31.0	17.0
13	ONI SHOGI	28+	18+	8+	5–	6–	16+	10–	4.0	29.5	15.0
14	SEKUSHII AICHAN	32+	4–	7+	12+	15–	21+	5–	4.0	28.0	14.0
15	AMANO SOFU	29+	10+	4–	3–	14+	12–	25+	4.0	28.0	13.5
16	YAMADA SHOGI	1–	27+	18+	26+	12–	13–	23+	4.0	27.5	13.0
17	AU AU SHOGI	23–	21+	12–	19+	33+	26+	7–	4.0	23.0	11.0
18	SUNDA SHOGI	5–	13–	16–	34+	32+	33+	21+	4.0	21.0	8.0
19	AOI B	9–	25=	36+	17–	11–	30+	27+	3.5	21.0	5.0
20	MARUDEN SHOGI	31+	35+	2–	1–	22+	6–	11–	3.0	28.0	6.0
21	MARUYAMA SHOGI	26+	17–	35+	11+	9–	14–	18–	3.0	25.0	8.5
22	SHUTO SHOGI	3–	34+	25+	7–	20–	8–	29+	3.0	25.0	6.5
23	100.EXE	17+	26–	6–	35+	8–	28+	16–	3.0	24.0	7.0
24	PIECE CAPTOR	7–	6–	32+	29+	27–	10–	31+	3.0	21.5	4.5
25	C-MODE	11–	19=	22–	10=	31+	29+	15–	3.0	23.5	4.0
26	NAGAYOSHI SHOGI	21–	23+	33+	16–	5–	17–	28+	3.0	22.5	6.5
27	YOKOYAMA SHOGI	36+	16–	9–	33+	24+	7–	19–	3.0	21.5	4.5
28	TSUBAKIHARA SHOGI	13–	5–	34+	32+	7–	23–	26–	2.0	23.5	3.5
29	NARIKIN SHOGI	15–	2–	30+	24–	35+	25–	22–	2.0	22.0	3.0
30	SHOGI MOBA	4–	32+	29–	8–	10–	19–	36+	2.0	22.0	2.0
31	U10	20–	33–	10–	36+	25–	34+	24–	2.0	16.5	1.5
32	MEIJIN KONTA	14–	30–	24–	28–	18–	36+	35+	2.0	16.0	1.0
33	JAVATAIKYOKU	35–	31+	26–	27–	17–	18–	34=	1.5	18.5	2.0
34	TOSHIZO SHOGI	8–	22–	28–	18–	36+	31–	33=	1.5	17.5	0.0
35	SUZUKI SHOGI	33+	20–	21–	23–	29–	11–	32–	1.0	19.0	1.5
36	TECC 1	27–	1–	19–	31–	34–	32–	30–	0.0	20.5	0.0

Table 1: Results of the First Qualification Round.
* YANO SHOGI 4, AMANO SHOGI, HYPER SHOGI 7, SPEAR, OJIRO, SUZU NO NE, USAPYON and TACOS qualify for the second qualification round.

The first preliminary tournament went more or less as expected. The winner of this stage was YANO SHOGI, which only drew against HYPER SHOGI (repetition of moves) and won all its other games. Second place was for AMANO SHOGI, only losing against SPEAR; due to a fortuitous draw it did not have to play YANO SHOGI. Third place was for HYPER SHOGI, a program that abandoned the second preliminary tournament last year. My program SPEAR ended in fifth place. This was the best possible result as my games against YANO SHOGI and HYPER SHOGI showed that there is still much work to do. Actually, I received more than I deserved, as SPEAR was completely lost in the second-round game against SEKUSHII AICHAN. Fifth place was for OJIRO, a program that also qualified last year. The programs on the places 6, 7 and 8 were all entries that cleared the first qualification stage for the first time. SUZU NO NE was sixth, USAPYON seventh and TACOS eight. The latter program is developed by the students of Hiroyuki Iida's group at Shizuoka University. In comparison, SUZU NO NE faced though opposition from two programs that ended in the top ten (it lost both of these games). Every year the pairings in the CSA tournament are a point of discussion and this year the programmers of S1.6 were unlucky. A draw in the second round against FUKU SHOGI decided their fate and in the last round they had to play AMANO SHOGI instead of one of their immediate rivals. In the end they had a huge SOS score, but just half a point failed to qualify (see Table 1).

The first preliminary round was much tougher than I expected. Nowadays many programs play a reasonable game of shogi and only 8 of them could qualify for the next stage. The average improvement in playing strength can be judged from looking at the results of ISOBE SHOGI (4.5 points), YAMADA SHOGI (4 points), MARUDEN SHOGI (3 points) and MARUYAMA SHOGI (3 points). These four programs all played in the second qualification round last year, but did not come close to qualification this year.

3. The Second Preliminary Stage

The second qualification round promised to be very interesting. Seven programs would qualify, but there were quite a large number of candidates. The favourites were, of course, KANAZAWA SHOGI and KAKINOKI SHOGI, but for the other places in the final a heated battle was expected. KFEND, SHOTEST and SHOCKY played in the final last year, but KCC SHOGI and GEKIZASHI were expected to do really well. Furthermore, EISEI MEIJIN, SOGIN and TANCHO are always very close to qualifying for the finals and might make it this time. Finally, YANO SHOGI, AMANO SHOGI and HYPER SHOGI had played well so far and would now be actually tested.

The first round had almost no surprises. The tournament confused the Shogi watchers in the second and the third round. Both KANAZAWA SHOGI and KAKINOKI SHOGI lost two games in a row! KCC SHOGI showed it was a favourite to win the title by first beating KAKINOKI SHOGI in round two and then KANAZAWA SHOGI in round three. KANAZAWA SHOGI had serious hardware problems, as the new processor they were using heated too much, which indirectly had caused the program to lose in the second round against TANCHO. From that moment on, KANAZAWA SHOGI played with a big electric fan pointing straight into the PC they were using. This makeshift measure was just sufficient to play a game without any overheating, but it must have been a torture to sit, wait and see whether the hardware would hold out or break down. KAKINOKI SHOGI lost its third-round game to GEKIZASHI and a sensational line-up for the final seemed to be in the making with KCC SHOGI, GEKIZASHI, SOGIN, EISEI MEIJIN and SHOCKY all starting with three wins. This group was followed by HYPER SHOGI, SHOTEST, YANO SHOGI and SUZU NO NE with two wins and one loss.

In round 4 KCC SHOGI lost surprisingly against HYPER SHOGI; most other games went as expected. GEKIZASHI beat SHOCKY and EISEI MEIJIN lost against SOGIN, cutting the group of leaders to two programs. The biggest surprise was the loss of TANCHO against USAPYON. TANCHO now had only one and a half points out of four games and seemed completely hopeless.

Rounds 5 and 6 brought bad news for GEKIZASHI and the two non-Japanese programs SHOTEST and SHOCKY. All three programs lost two games in a row and suddenly the tournament was exciting as there were no undefeated programs. KCC SHOGI, HYPER SHOGI and SOGIN led with 5 wins and one loss, followed by GEKIZASHI, KAKINOKI SHOGI, KANAZAWA SHOGI, YANO SHOGI, RYU NO TAMAGO and EISEI MEIJIN. Further down the table, SPEAR had recovered from a terrible 1-3 start (including a loss against KFEnd caused by the same bug that almost lost the game against AICHAN earlier). Two wins in row had brought all European programs on the same score, as SHOCKY and SHOTEST also had 3 wins and 3 losses.

In round 7, KCC SHOGI was the first program to secure a place in the final with a win over SOGIN. HYPER SHOGI lost against GEKIZASHI, leaving both programs with 5 wins and 2 losses. KANAZAWA SHOGI and KAKINOKI SHOGI completed their recovery by winning their fourth game in a row, sharing second place behind KCC SHOGI. Bad news for SHOTEST and SHOCKY, losing their third and fourth game in a row respectively. It looked like KCC SHOGI would be the only non-Japanese program in the final. Actually, at this point SPEAR was the European program with the best qualification chance, since it had won its third game in a row and now had 4 wins from 7 games.

KCC SHOGI also won in round 8, but it was more interesting to see what happened with the other programs. HYPER SHOGI beat SOGIN to qualify for the final. A great achievement by the program that seemed to have difficulties on the first day. GEKIZASHI also ended all doubts with an impressive victory over KANAZAWA SHOGI. By a win over RYU NO TAMAGO, KAKINOKI SHOGI qualified too. Four places in the final were decided, three places were still open. With six wins qualification was certain, but it was possible that one or two programs with 5 wins would qualify as well. There were still five programs with a qualification chance: Kanazawa Shogi (5 points), Sogin (5 points), Yano Shogi (5 points), Tancho (amazing recovery and 4 and half points) and Shotest (4 points). Spear was no longer among them with a loss against Takada Shogi. Due to number of weak opponents, 5 points would not be sufficient for Spear to qualify. Still, the final round was vital for me as well, since a win would secure a seeded place in the second qualification round next year.

The final round paired Kanazawa Shogi against Yano Shogi, Sogin against Tancho, and Shotest against Takada Shogi. Kanazawa Shogi beat Yano Shogi and the game Shotest - Takada Shogi was also over rather quickly: a win by Shotest. Many complicated calculations followed, the conclusion being that Sogin would qualify whatever the result of the last game. If Sogin would win, Shotest would be the program to qualify with five wins. If Tancho would win, Tancho would qualify. The game was a very long battle and for a long time it looked like Sogin was winning. However, Tancho managed to turn tables and qualify for the finals, which was almost unthinkable after its abysmal start. Tancho has been very close to the finals for years without quite making it, so it was good to see that the efforts of Todoroki-san finally were rewarded (see Table 2).

No	Program Name	1	2	3	4	5	6	7	8	9	Pts	SOS	SB
1	KCC Shogi	13+	4+	5+	2–	14+	8+	7+	11+	3+	8.0	49.0	42.0
2	Hyper Shogie 7	6+	10+	8–	1+	16+	14+	3–	7+	4+	7.0	48.5	37.5
3	Gekizashi	21+	12+	4+	14+	11–	7–	2+	5+	1–	6.0	49.0	31.0
4	Kakinoki Shogi	18+	1–	3–	9+	24+	15+	11+	10+	2–	6.0	45.5	24.5
5	Kanazawa Shogi	10+	6–	1–	24+	15+	11+	14+	3–	9+	6.0	44.0	24.5
6	Tancho under Reiki	2–	5+	23=	17–	8+	22+	15–	9+	7+	5.5	40.0	23.0
7	Sogin	16+	8+	12+	11+	9–	3+	1–	2–	6–	5.0	50.5	25.0
8	Shotest	19+	7–	2+	16+	6–	1–	9–	17+	15+	5.0	45.5	22.0
9	Yano Shogi	14–	17+	19+	4–	7+	12+	8+	6–	5–	5.0	43.5	22.0
10	Ryu no Tamago	5–	2–	13+	19+	17+	16+	12–	4–	20+	5.0	43.0	19.0
11	Eisei Meijin	20+	23+	24+	7–	3+	5–	4–	1–	17+	5.0	41.5	16.5
12	KFEnd	15+	3–	7–	13+	20+	9–	10+	14–	18+	5.0	41.0	21.0
13	SPEAR	1–	18+	10–	12–	22+	19+	16+	15–	14+	5.0	39.0	17.0
14	Shocky	9+	22+	17+	3–	1–	2–	5–	12+	13–	4.0	48.0	16.0
15	Takada Shogi	12	21+	16–	23+	5–	4–	6+	13+	8–	4.0	41.5	15.5
16	Suzu no ne	7–	19+	15+	8–	2–	10–	13–	20+	21+	4.0	40.0	13.0
17	Usapyon	22+	9–	14–	6+	10–	24+	21+	8–	11–	4.0	36.0	12.0
18	Sekita Shogi	4–	13–	21–	20+	19–	23+	24+	22+	12–	4.0	30.5	8.5
19	Nazoteki Denki	8–	16–	9–	10–	18+	13–	22–	23+	24+	3.0	33.5	7.5
20	Amano Shogi	11–	24–	22+	18–	12–	21+	23+	16–	10–	3.0	31.5	7.0
21	Ojiro	3–	15–	18+	22–	23+	20–	17–	24+	16–	3.0	30.5	7.5
22	Sakura	17–	14–	20–	21+	13–	6–	19+	18–	23–	2.0	33.5	6.0
23	Sakashita Shogi	24=	11–	6=	15–	21–	18–	20–	19–	22+	2.0	31.0	2.0
24	TACOS	23=	20+	11–	5–	4–	17–	18–	21–	19–	1.5	36.0	3.0

Table 2: Results of the Second Qualification Round.
*KCG Shogi, Hyper Shogi 7, Gekizashi, Kakinoki Shogi, Kanazawa Shogi, Tancho under Reiki and Sogin qualify for the finals.

4. The Finals

For the finals, the tournament hall had been turned into a perfect demonstration hall. Every round two huge projectors displayed two games on big screens and also two games were commented by the shogi professionals Katsumata and Sanada. Katsumata especially is very interested in computer shogi. For many years he has been a regular guest at the CSA tournament. Katsumata is a real entertainer, he has great knowledge and provides hilarious comments on the games.

The finals promised to be a direct face-off between IS Shogi, KCC Shogi and maybe YSS. Also, Gekizashi's performance would be watched closely. The first two rounds went almost completely as expected, with IS Shogi and KCC Shogi winning both their games. Kanazawa Shogi also started well. The win over YSS in the second round either indicated that they had managed to solve some of the problems overnight or that YSS was not as strong as expected. GEKIZASHI found tough opposition in the finals and lost twice. However, losing against IS SHOGI and KCC SHOGI cannot really be called upsets.

In round 3 GEKIZASHI showed what it can by beating KANAZAWA SHOGI, and followed this success in round 4 by a win over KAKINOKI SHOGI. After four rounds the tournament seemed to turn into a two horse race between IS SHOGI and KCC SHOGI, just as the television crew from Asahi television had hoped. These two programs were followed by KANAZAWA SHOGI and YSS, but from the way these two programs played so far, it seemed unlikely that they would catch up.

However, round 5 changed the opinion. KCC SHOGI obtained an overwhelming position against KANAZAWA SHOGI and at some point I was certain that the game would be over in a few moves. It did not happen. KANAZAWA SHOGI managed to stay alive, confusing KCC SHOGI just sufficiently by starting a kind of attack. KCC SHOGI had many chances to win, but continued to play the wrong attacking plans and after an heroic battle KANAZAWA SHOGI won the game. In the same round YSS lost against GEKIZASHI, who was suddenly making strong claims on a coveted third place that would mean automatic qualification for next year's finals.

Round 6 more or less ended all hopes for KANAZAWA SHOGI to obtain another CSA crown as IS SHOGI beat the program by six wins in a row. YSS lost against KCC SHOGI, so now it was really between IS SHOGI and KCC SHOGI for the championship with IS SHOGI having the advantage of being undefeated. This advantage was almost lost in round 7 as IS SHOGI came very close to losing against KAWABATA SHOGI. So far, KAWABATA SHOGI had not caused quite a stir with its two wins, against SOGIN and TANCHO. However, the game against IS SHOGI was different. At some point there was even a forced win for KAWABATA SHOGI, but the program did not find it. IS SHOGI desperately defended and when KAWABATA SHOGI got into time trouble, things slowly started to turn. In the end IS SHOGI won the game, but KAWABATA SHOGI showed in this game that the program is stronger than the number of wins might indicate.

Round 8 saw the long awaited battle between the team of Tokyo University and the North Koreans. If IS SHOGI would win this game, it would win the championship for the second year in a row. However, if KCC SHOGI would win, it could win the title by a victory over KAWABATA SHOGI in the final round. It was a very high-level game. After some initial fighting, IS SHOGI got some advantage, but KCC SHOGI did everything to stay in the game. IS SHOGI could not find the best winning plan and KCC SHOGI's counter attack, which had seemed very slow, suddenly started to look very dangerous. In the end IS SHOGI just managed to give its attack winning strength and decided the game with one move difference. So, the old world computer-shogi champion is also the new world champion and the computer-shogi world has to wait at least another year for its first non-Japanese tournament winner.

The final round had no surprises as all top programs won. IS SHOGI therefore won the title with a perfect score, but it was a little surprising to see KANAZAWA SHOGI in second place. The win against KCC SHOGI turned out to be a vital one, as KANAZAWA SHOGI just managed to pass the Koreans on SB points. Fourth place was for GEKIZASHI, followed by YSS and KAKINOKI SHOGI. After these programs there was a two point gap to KAWABATA SHOGI, HYPER SHOGI and SOGIN with TANCHO ending in last place (see Table 3).

5. Conclusions

I believe all programs have increased considerably playing strength when compared to last year. This is best illustrated by the performance of KAWABATA SHOGI and SHOTEST. Both Kawabata and Jeff had almost no time to work on their programs in the past year and both programs did much worse than last year. I followed almost all games of IS SHOGI in the finals and I was impressed by the way this program plays. It still has some weaknesses in the opening and middle game, but especially in the endgame it is almost unbeatable. Tanase, a reasonable player himself, told me that he has already given up on trying to understand the program's play in the endgame as he found that the program sees much more than he does.

Another observation is that computer shogi is becoming more and more a team effort. Improving different parts of a shogi program seems to be too complicated to do by one person. The first four programs in this tournament all were developed by a team. Most impressive is of course the manpower that was put into KCC SHOGI, but it seems that winning the CSA tournament on your own is almost impossible. Maybe it is time to think about combining the skills of the programmers from Europe (Jeff, Pauli and me) and create an EURO Shogi program.

This might be the only way to break the Asian supremacy.

No	Programs	1	2	3	4	5	6	7	8	9	Pts	SB
1	IS SHOGI	9+	4+	6+	10+	8+	2+	7+	3+	5+	9	36
2	KANAZAWA SHOGI	8+	5+	4–	7+	3+	1–	10+	9+	6+	7	23
3	KCC SHOGI	4+	6+	10+	9+	2–	5+	8+	1–	7+	7	22
4	GEKIZASHI	3–	1–	2+	6+	5+	7+	9+	10–	8+	6	22
5	YSS 11	10+	2–	9+	8+	4–	3–	6+	7+	1–	5	11
6	KAKINOKI SHOGI	7+	3–	1–	4–	9+	10+	5–	8+	2–	4	7
7	KAWABATA SHOGI	6–	9+	8–	2–	10+	4–	1–	5–	3–	2	3
8	HYPER SHOGI 7	2–	10+	7+	5–	1–	9–	3–	6–	4–	2	3
9	SOGIN	1–	7–	5–	3–	6–	8+	4–	2–	10+	2	3
10	TANCHO UNDER REIKI	5–	8–	3–	1–	7–	6–	2–	4+	9–	1	6

Table 3: The final results.

6. The Programs

IS SHOGI: Winning the CSA tournament without losing a single game is impressive, especially with the high level of competition these days. Last year I thought the program still showed some weaknesses, but this year IS SHOGI was one level stronger than all the other programs.

KANAZAWA SHOGI: To me Kanazawa's runner-up finish was a big surprise. KANAZAWA SHOGI seemed to be handicapped in this tournament, either by malfunctioning hardware or by bad shogi positions. The team was either lucky or had worked very hard in the night before the finals to fix most of the problems. The results show that it is not necessarily a bad thing to play the qualification tournament, as long as there is time to fix bugs.

KCC SHOGI: The program was in the centre of attention during the whole tournament. Not only the TV crew was following it but many spectators as well. It had vastly improved over last year's version and it could only be stopped by IS SHOGI. Apparently KCC is prepared to put a great deal of money in this project, as they even hired people from the Niigata shogi club to build an opening book with more than a million positions. KCC SHOGI is already favourite to win next year's tournament.

GEKIZASHI: This program is searching extremely deep and accurate. If weaknesses in the opening can be improved, this program is a dark horse for the title. A problem will be how much time the team can spent on shogi programming. GEKIZASHI is developed by students from Tokyo University, Japan's most prestigious university. This means that at some point they will have to choose between shogi programming and a *normal* career. Many graduates from Tokyo University keep good jobs in Japan, so it will not be an easy decision.

YSS: This year's performance was a little disappointing. YSS beat all programs that ended below in the table, but did not achieve a single win against one of the favourites. Maybe Yamashita's efforts on the Go program AYA took too much time. I think it might be a good idea to form a team to come back in the ranks of the favourites.

KAKINOKI SHOGI: Every year, KAKINOKI SHOGI qualifies for the finals without too much effort. This is of course a great result in itself, but after that it never gets into a position to win a title. Maybe Kakinoki and Yamashita should team up.

KAWABATA SHOGI: Last year KAWABATA SHOGI achieved a great performance by a third place, but after that Kawabata had almost no time to work on the program. In the end he played with more or less the same version as last year and this resulted in only two wins.

HYPER SHOGI: For me this program was the surprise of the tournament. Especially, its performance on the second day was outstanding and it needs just a little bit more to compete with the frontranked programs on equal footing.

SOGIN: SOGIN looked very good in its first six games, winning five of them. However, after that it only won two more games of the remaining twelve. A stable program, but in its current form it does not look like it will go any further than being on the border line of qualification for the finals every year.

TANCHO: Was a little lucky to reach the finals and seemed to be the weakest program of the ten finalists. Still, it managed to avoid losing all games with a fine win over GEKIZASHI.

REPORT ON THE 1ST INTERNATIONAL CSVN TOURNAMENT

Leiden, The Netherlands
18-20 May 2001

Th. van der Storm[1]

Amsterdam, The Netherlands

In addition to our annual Open Dutch Computer-Chess Championship held since 1981, the CSVN wished to create another event in the spring. The new event is preferred by foreigners due to the fact that it is played in a consecutive number of days instead of two weekends. The playing tempo of 90 minutes per player for the whole game allowed for a 9-round Swiss-system tournament in 3 days at the *Leids Denksportcentrum*. Table 1 contains information on the participants and Table 2 contains the results.

The first big surprise in the first round was QUARK's (Thomas Mayer) win against THE KING (Johan de Koning). A Rook in front of THE KING's own king-side Pawns was unable to assist in the defence. Vincent Diepeveen's program DIEP had a very good start, but lost a rook ending against INSOMNIAC in the 4th round. He finished third with 5.5 points.

NAME	Hardware	Team	Place
31337/CELES	AMD Athlon 800 MHz, 128 MB	Johan Hutting, Marcel Veldhuizen (GUI)	Leeuwarden, NL
ANT	Pentium IV 1500 MHz	Tom Vijlbrief, Hans Secelle, and Albrecht Heeffer	Baarn, NL Schelderode, Belgium
CRUX	AMD Duron 750 MHz	László Szalai	Hungary
DIEP	quad Xeon 700 MHz	Vincent Diepeveen	Veenendaal, NL
FRITZ	Dual Pentium III, 1000 MHz	Frans Morsch, Mathias Feist, and Alex Kure (book)	Dronten, NL Germany
GAMBIT TIGER 2.0	Pentium III, 1200 MHz, 128 MB	Christophe Théron, Jeroen Noomen (book)	Gosier, Guadeloupe Apeldoorn, NL
GOLDBAR	Athlon Thunderbird 1200	Bart Goldhoorn	Almere, NL
GOLIATH CHESS X	Pentium III, 1000 MHz	Michael Borgstädt Erdogan Günes	Hamburg, Germany
INSOMNIAC	AMD Athlon 1300 MHz	James Robertson	Riverside CA, USA
ISICHESS X	AMD Athlon 1200 MHz	Gerd Isenberg	Essen, Germany
MAT(H)!	Pentium III, 1000 MHz	Andy Van De Putte	Assenede, Belgium
PATZER	dual Pentium III 1075 MHz, 600 MB	Roland Pfister, Frank Quisinsky	Frankfurt, Germany Trier, Germany
QUARK	Pentium III 933 MHz	Thomas Mayer, Leo Dijksman (book)	Germany
SOS	Pentium, Dual 800 MHz	Rudolf Huber	Munich, Germany
SPIDERGIRL	AMD 1200 MHz, 48 MB	Martin Giepmans	Nijmegen, NL
TAO	(Pentium III 500 Mhz)	Bas Hamstra, Cock de Gorter (book)	Groningen, NL
THE KING	(AMD, 1300 MHz, 30MB)	Johan de Koning, Cock de Gorter (book)	Delft, NL
XINIX	AMD Athlon 1200 MHz, 128 MB	Tony Werten	Eindhoven, NL
YACE	AMD 1000 MHz	Dieter Bürßner, Jan Kaan (book)	Konstanz, Germany

Table 1: Participants of the 1st International CSVN Tournament.

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The favourites for first place met in the 4th round: FRITZ and GAMBIT TIGER 2.0. FRITZ made a big mistake by playing b4, trapping, although not losing, his own Queen at a5 within Pawns. Nonetheless the game still lasted another 29 moves before GAMBIT TIGER 2.0 won. In the end FRITZ proved to be a merciless opponent winning all other games.

No.	NAME	R1	R2	R3	R4	R5	R6	R7	R8	R9	Pt	BP
1	FRITZ	11w1	7b1	9w1	2w0	12b1	5b1	3w1	6w1	8b1	8.0	45.5
2	GAMBIT TIGER 2.0	16b1	14w1	3w=	1b1	7w1	6b1	8w=	5b1	10w1	8.0	45.0
3	DIEP	17w1	4w1	2b=	7b0	9w1	15w1	1b0	10b0	6w1	5.5	47.5
4	YACE	15w1	3b0	11w1	9b1	6w0	7b=	5w0	12b1	14b1	5.5	40.0
5	THE KING	14b0	bye1	10w1	12w=	13b1	1w0	4b1	2w0	7b=	5.0	48.5
6	PATZER	13b=	18w1	12b=	14w1	4b1	2w0	7w1	1b0	3b0	5.0	47.5
7	INSOMNIAC	19w1	1w0	16b1	3w1	2b0	4w=	6b0	11b1	5w=	5.0	44.0
8	SOS	10b0	17w=	14b0	18b1	16w1	12w1	2b=	13w1	1w0	5.0	42.5
9	TAO	bye1	10w1	1b0	4w0	3b0	11b=	14w1	16b=	18w1	5.0	42.5
10	GOLIATH CHESS X	8w1	9b0	5b0	11w=	19b1	13w=	15b1	3w1	2b0	5.0	40.0
11	ISICHESS X	1b0	15w1	4b0	10b=	17w1	9w=	13b=	7w0	bye1	4.5	43.0
12	ANT	18b=	13w1	6w=	5b=	1w0	8b0	bye1	4w0	17b1	4.5	42.5
13	SPIDERGIRL	6w=	12b0	19w1	17b1	5w0	10b=	11w=	8b0	16w1	4.5	34.0
14	QUARK	5w1	2b0	8w1	6b0	15b0	18w1	9b0	19b1	4w0	4.0	39.5
15	GOLDBAR	4b0	11b0	bye1	16w1	14w1	3b0	10w0	18b0	19w1	4.0	34.0
16	XINIX	2w0	19b1	7w0	15b0	8b0	bye1	17w1	9w=	13b0	3.5	37.0
17	CRUX	3b0	8b=	18w1	13w0	11b0	19w1	16b0	bye1	12w0	3.5	32.5
18	MAT(H)!	12w=	6b0	17b0	8w0	bye1	14b0	19w1	15w1	9b0	3.5	32.5
19	31337/CELES	7b0	16w0	13b0	bye1	10w0	17b0	18b0	14w0	15b0	1.0	31.5

Table 2: Results of the 1st International CSVN Tournament.

Finally, we note that a player obtains only half a Buchholz point for an opponent's bye point. This ruling decided the outcome in favour of FRITZ. For more information and all games see the new official website of the CSVN: www.computerschaak.nl

SELECTED GAMES

Below we provide four interesting games from the tournament.

FRITZ - GAMBIT TIGER 2.0 (round 4)

1. d4 d5 2. c4 dxc4 3. e4 Nc6 4. Be3 Nf6 5. Nc3 e5 6. d5 Na5 7. Nf3 Bd6 8. Qa4+ Bd7 9. Qxa5 a6 10. Na4 Qe7 11. a3 Nxe4 12. Bxc4 b5 13. Bd3 Nf6 14. Nc3 e4 15. Nxe4 Nxe4 16. O-O O-O 17. Rfe1 f5 18. h3 Qf7 19. Rad1 Rfe8 20. Bc2 g6 {**See Diagram 1**} 21. b4 Nc3 22. Rd3 Qg7 23. Bd1 Ne4 24. Bd4 Qf7 25. Rde3 g5 26. Bc2 g4 27. hxg4 fxg4 28. Bxe4 gxf3 29. Bxf3 Qf4 30. Bc5 Qh2+ 31. Kf1 Bf4 32. Rxe8+ Bxe8 33. Be3 Bd6 34. Ke2 Bh5 35. Rd1 Qe5 36. Rd4 Bxf3+ 37. gxf3 Qf5 38. Rd3 h5 39. a4 h4 40. axb5 h3 41. Qa1 h2 42. b6 cxb6 43. Qh1 Rc8 44. f4 Qh5+ 45. Kf1 Rc2 46. Bd2 Bxf4 47. d6 Rxd2 48. Rxd2 Bxd2 49. d7 Qd1+ 50. Kg2 Qxh1+ 0-1

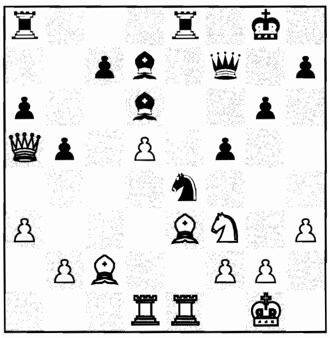


Diagram 1: After 20. … g6.

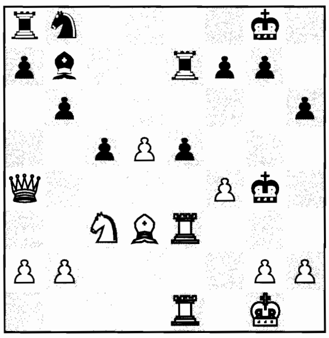


Diagram 2: After 19. Rfe1.

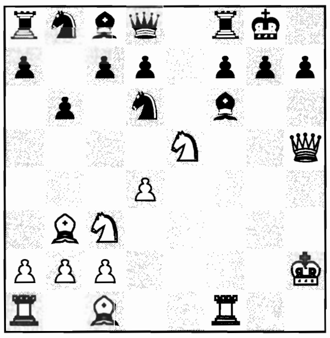
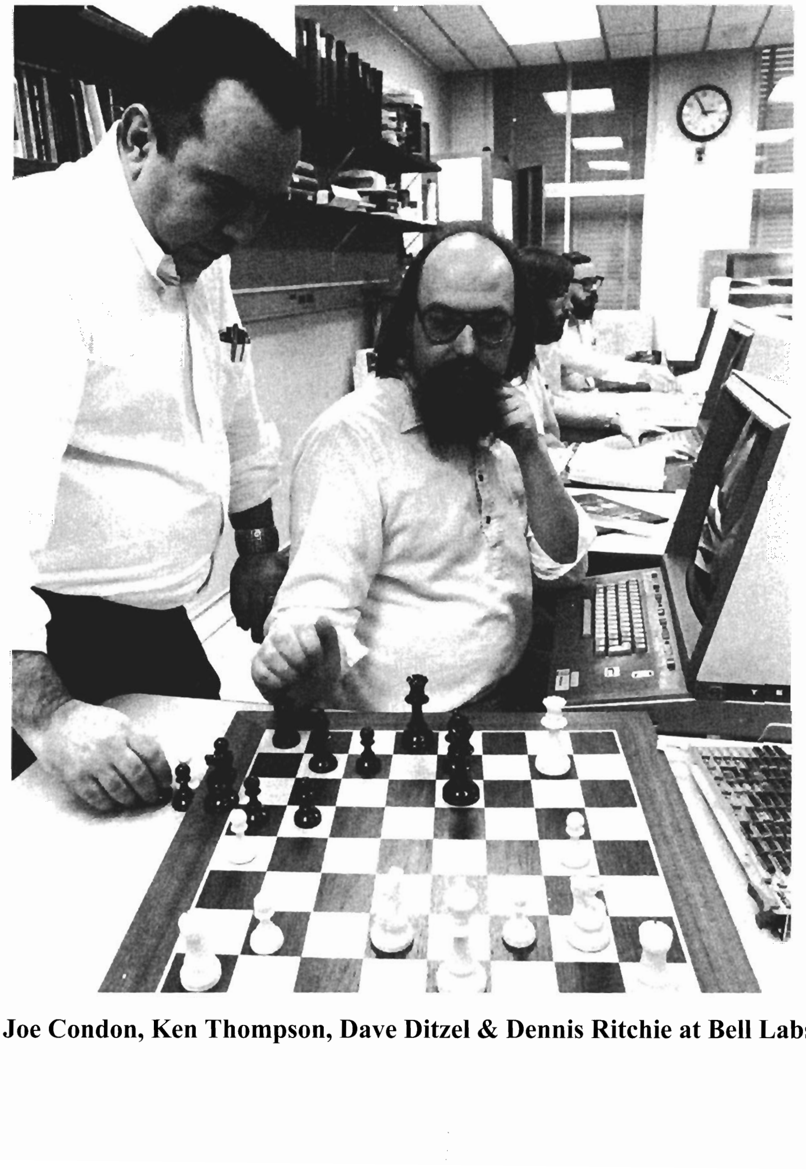


Diagram 3: After 13. Kxh2.

DIEP - YACE (ROUND 2)
1. d4 Nf6 2. c4 c5 3. d5 e6 4. Nc3 exd5 5. cxd5 Bd6 6. Bg5 O-O 7. e3 h6 8. Bxf6 Qxf6 9. Nf3 b6 10. Qa4 Re8 11. Bd3 Be5 12. Nxe5 Rxe5 13. O-O d6 14. Rae1 Bb7 15. f4 Re7 16. e4 Qg6 17. Re3 Qg4 18. e5 dxe5 19. Rfe1 {**See Diagram 2**} 19... Qd7 20. Bb5 Qd6 21. Rxe5 Rxe5 22. Rxe5 Qf6 23. Re8+ Kh7 24. Qe4+ g6 25. Qe5 Qg7 26. Ne4 Qxe5 27. fxe5 Kg7 28. Nf6 Na6 29. Rxa8 Bxa8 30. Bxa6 Kf8 31. Bb5 Bb7 32. d6 Bc8 33. d7 Bxd7 34. Nxd7+ Ke7 35. Nb8 Ke6 36. Nc6 a5 37. Bc4+ Kd7 38. Na7 a4 39. Bxf7 Ke7 40. e6 c4 41. Nc8+ Kf6 42. Nxb6 a3 43. Nxc4 1-0

TAO -QUARK (round 7)
1. e4 e5 2. Bc4 Nf6 3. f4 Nxe4 4. Nc3 Nd6 5. Bb3 exf4 6. Nf3 Be7 7. Ne5 Bh4+ 8. g3 fxg3 9. O-O gxh2+ 10. Kh1 O-O 11. Qh5 Bf6 12. d4 b6 13. Kxh2 {**See Diagram 3**} 13... Ba6 14. Rf3 Bxe5+ 15. dxe5 g6 16. Qh6 Qe7 17. exd6 Qxd6+ 18. Bf4 Qd4 19. Ne4 Bf1 20. Raxf1 1-0

INSOMNIAC - FRITZ (round 2)
1. e4 c5 2. Nf3 d6 3. d4 cxd4 4. Nxd4 Nf6 5. Nc3 Nc6 6. Bg5 e6 7. Qd2 a6 8. O-O-O h6 9. Be3 Be7 10. f4 Nxd4 11. Bxd4 b5 12. Qe3 Bb7 13. Bxf6 gxf6 14. Bd3 Qc7 15. Kb1 b4 16. Ne2 h5 17. c4 bxc3 18. Nxc3 Qc5 19. Qh3 Rb8 20. Rc1 Qa5 21. Rhd1 h4 22. Rc2 Rc8 23. f5 Qe5 24. g3 Bd8 25. gxh4 Ba5 26. Rdc1 Rg8 27. fxe6 fxe6 28. Rg2 Kd7 29. Rxg8 Rxg8 30. Qf3 Bxc3 31. Rxc3 Rg1+ 32. Kc2 Rg7 33. Qf2 Ke8 34. Kb3 Bxe4 35. Rc8+ Kd7 36. Bxa6 Bd5+ 37. Ka3 Bb7 38. Rc4 Ke8 39. Bxb7 Rxb7 40. b4 Qb5 41. Qe2 Kd7 42. Qd3 d5 43. Rd4 Qxd3+ 44. Rxd3 Kd6 45. h5? e5 46. Rh3 e4 47. h6 Rh7 48. Kb3 d4 49. b5 f5 50. Rh4 d3 51. Kc3 Rc7+ 52. Kd2 Rc2+ 53. Kd1 Ke6 54. Rh3 f4 55. Rxd3 0-1



BELLE, Joe Condon, Ken Thompson, Dave Ditzel & Dennis Ritchie at Bell Labs (1978)

REPORT ON THE FIRST ITALIAN COMPUTER-CHESS CHAMPIONSHIP

Pisa, Italy
19-20 May, 2001

Gianluigi Masciulli[1]

Prato, Italy

The first Italian Computer-Chess Championship was hosted by the "Centro Sportivo Portanuova", a nice location in the centre of Pisa three minutes walking from the Leaning Tower. The tournament was a 5-round Swiss-pairing system, open to Italian programs only. The time was 80 minutes per game plus 10 seconds for each move. This proved to be a comfortable time control and no games were forfeited on time. The Championship was made possible by the efforts of Carmelo Calzerano, Francesco Rinaldi, myself, and all the participants. Actually, we can say that it has been organized by the "gSei[2]", a collective name we use to indicate the active chess programmers in Italy. All the gSei programmers (see Table 1) were present except for one, Mauro Scarpa. The tournament went very smoothly and the atmosphere was friendly. Arbiters were Ivo Fasiori and Francesco Rinaldi. Ciro Vignotto operated the pairing program "Diena". The event is covered, in Italian, by the site www.gsei.org and, in English, by the Golem Home Page www.geocities.com/gmasciulli.

Program	Version	Author	Hardware [3]	Operated by
ALDEBARAN	0.5.3	Mauro Scarpa	Pentium II 266 Mhz	Daniele Cazzaro
CYBERPAGNO	0.5	Marco Pagnoncelli	Celeron 500 Mhz	
ESC	0.30a	Claudio della Corte	Pentium III 600 Mhz, 128Mb Hash 56Mb, 4-men tablebases	
GOLEM	0.4	Gianluigi Masciulli	Pentium III 800 Mhz	G.Giovannini, G.Stilli
LARSENVB	0.4	Luca Dormio	Athlon 1Ghz	
LEILA	0.33c	Carmelo Calzerano	Athlon 600 Mhz, 256 Mb Hash 88Mb, 5/4-men tablebases	Ciro Vignotto
MARONTI	0.5	Luca Damiani	K6-II 3D 450 Mhz	
RAFFAELA	0.0.6	Stefano Gemma	Pentium III 800 Mhz	
RINKO	1.02	Marco Grella	Duron 800MHz, 128MB Hash 50Mb	

Table 1: Participants of the first Italian Computer-Chess Championship.

The favourite was LEILA, winner of a recent "First Italian Engine Contest" on FICS. LEILA confirmed the prognostics by winning the tournament with the perfect score of 5 wins out of 5 games (see Table 2). Its first victim was ALDEBARAN and it subsequently defeated every program it met. Positive surprises were the new programs ALDEBARAN, CYBERPAGNO, MARONTI, and RINKO. Especially RINKO did well by taking the second place. ESC confirmed its strength, and MARONTI's solid play was another positive surprise. CYBERPAGNO and ALDEBARAN showed large possibilities for improvement considering that they were not completed. The fifth place was for LARSENVB, a program written in Visual Basic. I am quite happy with the ranking of my program GOLEM, which was clever to win a KNP-KN final against ALDEBARAN in the last round. About RAFFAELA I can say that it showed a very speculative play. Against GOLEM it was unlucky and did not convert an almost won game into a real won game. Note that RAFFAELA had no book, so the trick was found when playing (see below).

RAFFAELA-GOLEM (round 3)
1. e4 Nc6 2. d4 d5 3. exd5 Qxd5 4. Nc3 Qxd4 5. Be3 Qb4 6. a3 Qxb2 7. Nb5 Qe5 8. Nf3 Qd6 9. Nxd6+ exd6. GOLEM is already lost but the game ended via a draw by threefold repetition. Looking at the whole tournament, it is clear that computer chess in Italy has a long way to go before being competitive at international level, except for LEILA maybe. If the growth in playing strength continues at the rate of this year, we hope that the

[1] Via Pollative, 46/B 59100 Prato, Italy. Email: gmasciulli@libero.it.
[2] Acronym for "Gruppo Scacchi e Informatica" (aka g6).
[3] The memory is indicated only for programs using hash tables.

gap will be closed quickly. May be the second Italian computer-chess championship, planned for May 2002, will tell us whether this is true.

No	PROGRAM	1	2	3	4	5	Score	BP[1]
1	LEILA 0.33C	9B+	8W+	3B+	2B+	7W+	5.0	10.5
2	RINKO 1.02	7W+	5B+	4B+	1W-	3B=	3.5	14.0
3	ESC 0.30A	8B+	6W+	1W-	5B+	2W=	3.5	13.5
4	MARONTI 0.5	5W-	7B+	2W-	6B+	8W+	3.0	10.5
5	LARSENVB 0.4	4B+	2W-	9W=	3W-	X+	2.5	11.5
6	GOLEM 0.4	X+	3B-	8B=	4W-	9W+	2.5	9.5
7	CYBERPAGNO 0.5	2B-	4W-	X+	9B+	1B-	2.0	13.0
8	RAFFAELA 0.0.6	3W-	1B-	6W=	X+	4B-	1.5	14.0
9	ALDEBARAN 0.5.3	1W-	X+	5B=	7W-	6B-	1.5	12.0

Table 2: Results of the first Italian Computer-Chess Championship.

SELECTED GAMES

Below we provide four interesting games from the tournament.

ESC-LEILA (round 3)
1. c4 c6 2. Nf3 d5 3. d4 dxc4 4. e3 b5 5. a4 e6 6. b3 cxb3 7. axb5 Bb4+ 8. Bd2 Bxd2+ 9. Nbxd2 b2 10. Ra2 Nf6 11. Rxb2 O-O 12. Ne5 cxb5 13. Qf3 Qd5 14. Bxb5 Qxf3 15. Ndxf3 Ba6 16. Bxa6 Nxa6 17. Ng5 Nd5 18. Ngxf7 Rac8 19. Kd2 Rxf7 20. Nxf7 Kxf7 21. Rhb1 Rc7 22. e4 Nb6 23. Kd3 Na4 24. Rc2 Rxc2 25. Kxc2 Nb6 26. Rc1 Nb8 27. Kd3 a5 28. f4 a4 29. g4 g6 30. e5 Nd5 31. Ke4 a3 32. f5 a2 33. h3 Nb4 34. Ra1 N8c6 35. fxe6+ Kxe6 36. Rxa2 Nxa2 37. d5+ Kd7 38. dxc6+ Kxc6 39. h4 Nc3+ 40. Kf4 h6 41. h5 Nd5+ 42. Ke4 gxh5 43. gxh5 Ne7 {White resign} 0-1

MARONTI-RINKO (round 3)
1. e4 d6 2. d4 g6 3. Nf3 Bg7 4. Be3 Nf6 5. Bb5+ Nbd7 6. Nc3 O-O 7. O-O c6 8. Bd3 e5 9. d5 cxd5 10. exd5 b6 11. Re1 Bb7 12. Be4 Nxe4 13. Nxe4 Nc5 14. Bxc5 dxc5 15. c4 Qb8 16. g4 f5 17. gxf5 gxf5 18. Nc3 e4 19. Ng5 Bxc3 20. Qh5 Qc7 21. Ne6 Qf7 22. Qxf7+ Rxf7 23. bxc3 Ba6 24. a3 Bxc4 25. Nf4 Rd8 26. Red1 Bb3 27. Kh1 Bxd1 28. Rxd1 Re7 29. Re1 Kf7 30. Kg2 c4 31. Kf1 Kf6 32. Ke2 Rg8 33. Ke3 Rg4 34. h3 Rh4 35. d6 Rd7 36. Rd1 Kg5 37. Rg1+ Kh6 38. Rd1 a5 39. a4 Kg5 40. Rg1+ Kh6 41. Rd1 Kg7 42. Rd5 Kf6 43. Rd4 Kg5 44. Rd1 Rh6 45. Rg1+ Kh4 46. Rd1 Rhxd6 47. Rb1 Kg5 48. Rg1+ Kf6 49. Rb1 Rb7 50. h4 Rb8 51. Rb5 h6 52. Nd5+ Kf7 53. Nf4 Rf6 54. Nh5 Rg6 55. Rxf5+ Ke7 56. Nf4 Rd6 57. Re5+ Kd7 58. Rxe4 Re8 59. f3 Rxe4+ 60. fxe4 Rd1 61. e5 Kc6 62. h5 Kc5 63. Ke4 Re1+ 64. Kf5 Re3 65. Ne6+ Kc6 66. Ng7 Rxc3 67. e6 Re3 68. Kf4 Re1 69. Nf5 c3 70. Ne3 Re2 71. Kf3 c2 72. Nxc2 Rxc2 73. Kf4 Rc5 74. e7 Kd7 75. e8=Q+ Kxe8 76. Kg4 b5 77. axb5 Rxb5 78. Kf4 a4 79. Ke4 a3 80. Kf4 a2 81. Ke4 a1=Q 82. Ke3 Qb2 83. Kd3 Re5 84. Kc4 Rf5 85. Kd3 Rf4 86. Ke3 Qd4+ 87. Ke2 Rf2+ 88. Ke1 Qd2# {Black mates} 0-1

LARSENVB-ESC (round 4)
1. Nf3 Nf6 2. d4 e6 3. Bg5 Be7 4. e3 b6 5. Bd3 Bb7 6. Nc3 d5 7. O-O Nc6 8. Ne5 Nxe5 9. dxe5 Nd7 10. Bxe7 Qxe7 11. Qh5 O-O-O 12. Qg4 g6 13. Qa4 Nxe5 14. Qxa7 Nxd3 15. cxd3 Bc6 16. Rac1 h6 17. Ne2 Kd7 18. Nd4 Ra8 19. Nxc6 Rxa7 20. Nxe7 Kxe7 21. d4 Rc8 22. a3 c6 23. f4 f6 24. Rc2 h5 25. Rfc1 Kd6 26. h4 Rac7 27. Rc3 c5 28. Rb3 Kc6 29. dxc5 bxc5 30. Rbc3 Kd6 31. g3 c4 32. Kf2 e5 33. R3c2 d4 34. Rd1 d3 35. Kf3 f5 36. Kg2 e4 37. Kf2 c3 38. a4 cxb2 39. Rxb2 Rc2+ 40. Rxc2 Rxc2+ 41. Kf1 Rh2 42. Re1 Kc5 43. Kg1 d2 44. Rd1 Re2 45. Kf1 Rxe3 46. Rxd2 Rxg3 47. Rg2 Rg4 48. Rxg4 hxg4 49. Kf2 {White resigns} 0-1

GOLEM-ALDEBARAN (round 5)
1. e4 d5 2. exd5 Qxd5 3. Nc3 Qa5 4. d4 e5 5. dxe5 Qxe5+ 6. Be2 Bb4 7. Bd2 Bg4 8. Kf1 Bxe2+ 9. Ngxe2 Na6 10. a3 Bd6 11. Bf4 Qe6 12. Bxd6 Qxd6 13. Qxd6 cxd6 14. Nb5 Ke7 15. Rd1 Nh6 16. Rxd6 Rad8 17. Rxd8 Rxd8 18. Ke1 Ra8 19. Ned4 Nc5 20. Kd2 a6 21. Re1+ Kf8 22. Nc7 Rd8 23. c3 Nb3+ 24. Kd3 Nf5 25. Re5 Nfxd4 26. cxd4 Nxd4 27. Rd5 Nc6 28. Rxd8+ Nxd8 29. Nd5 f5 30. Ne3 Ne6 31. b3 b5 32. Nxf5 Nf4+ 33. Ke4 Nxg2 34. f4 h5 35. Ke5 h4 36. Nd4 Kf7 37. h3 Ne3 38. Ke4 Nd1 39. Kf3 Nc3 40. Kg4 Nb1 41. a4 bxa4 42. bxa4 a5 43. Nb3 Ke6 44. Kxh4 Kf5 45. Nxa5 Nc3 46. Nb3 Ne2 47. a5 Kxf4 48. Nc5 g5+ 49. Kh5 Kf5 50. a6 Nf4+ 51. Kh6 Nd5 52. a7 Nb6 53. Kg7 Na8 54. Kf7 g4 55. hxg4+ Kg5 56. Ke6 Kxg4 57. Kd5 Kf5 58. Na4 Nc7+ 59. Kc6 Ne8 60. a8=Q Nf6 61. Qa5+ Kf4 62. Nc3 Ng4 63. Kd6 Ke3 64. Qg5+ Kd3 65. Nd5 Nf2 66. Qe3+ Kc2 67. Qxf2+ Kb3 68. Kc5 Ka4 69. Qa2# {White won} 1-0

[1] Buchholz Points are computed by summing all the opponents results except the worst.

THE CMG SIXTH COMPUTER OLYMPIAD

Maastricht, The Netherlands
August 18-23, 2001

H.J. van den Herik[1]

Maastricht, The Netherlands

RULES OF THE CMG SIXTH COMPUTER OLYMPIAD

1. Each entry is a computing system and one or more humans who programmed it. At least one of the program developers should attend the Computer Olympiad to operate the program, otherwise the entry fee for the program is doubled.
2. Each program must be the original work of the entering developers. Programming teams whose code is derived from or including game-playing code written by others must name all other authors, or the source of such code, in their application details. Programs which are discovered to be close derivatives of others (e.g., by playing nearly all moves the same), may be declared invalid by the Tournament Director after seeking expert advice. For this purpose a listing of all game-related code running on the system must be available on demand to the Tournament Director.
3. Participants are required to attend an organisational meeting prior to the start of the tournament on August 19, 2001 for the purpose of officially registering for the tournament. Operational rules will be finalized at that meeting.
4. The format of each tournament and the rate of play will generally be determined by the Tournament Director according to the number of programs entered and any other relevant factors. The World Microcomputer Chess Championship will be a Swiss system event with 9 rounds in which the rate of play will be 60 moves in 2 hours followed by the rest of the game in 30 minutes.
5. Unless otherwise stated the rules of play for a tournament will be identical to those of human tournament play. In the case of games where there has been little or no previous experience of computer tournament play (e.g., Gipf), the rules will be determined by the Tournament Director after discussion with the competing programmers.
6. If the situation warrants it the Tournament Director has the right to adjudicate a game after 4 or more hours of play. All adjudications will be made on the assumption of perfect play. The Tournament Director may ask for expert advice as he sees fit. For chess, we refer to rule 4 (only in exceptional cases rule 6 applies).
7. An operator may ask the Tournament Director to stop the clocks at most twice during a game because of technical problems. The operator can ask the Tournament Director for permission to restart the program. When restarting after a failure of any kind the operator must reset all parameters to their values at the time the game was interrupted. Play must resume after at most a delay of 15 minutes.
8. All computers must be on site in the playing hall. All participants are required to make their own arrangements for computers though in exceptional cases (e.g., participants from countries which do not permit the temporary export of computers) the organisers will assist participants in arranging the loan of computers.
9. In the World Microcomputer Chess Championship all chess-playing code must execute on a single (locally present) computer system. A multi-processor system is allowed.
10. An operator error made when starting a game or in the middle of a game can be corrected only with the approval of the Tournament Director. If an operator enters an incorrect move, the Tournament Director must be notified immediately. Both clocks will be stopped. The game must then be backed up to where the error occurred. Clocks will be corrected and their settings when the error occurred using whatever information is available. Both (all) sides may then adjust their program parameters with the approval of the

[1] Tournament Director of the CMG 6th Computer Olympiad. Department of Computer Science, Universiteit Maastricht, P.O. Box 616, 6200 MD Maastricht, The Netherlands. Email: herik@cs.unimaas.nl.

Tournament Director. The Tournament Director may allow certain program parameters to be changed, e.g., contempt factors.

11. All monitors must be positioned so that the operator's activities are clearly visible to the opponent. An operator may only: [a] enter moves, and [b] respond to a request from the computer for clock information. This latter activity must be observed by the Tournament Director or his designate. If an operator needs to enter other information, it must be approved ahead of time by the Tournament Director. The operator may not query the system to see if it is alive without the permission of the Tournament Director.
12. A team must receive permission from the Tournament Director to change from one computing system to another.
13. Each game must be played using game equipment (e.g., boards, sets and clocks) provided by or approved by the event organisers. At the end of each game or playing session the teams are required to hand in a game listing or similar record to the Tournament Director.
14. Tie-breaking systems will be announced at the start of each tournament.
15. In the event of any rule disputes or changes necessitated by circumstances at the time, the Tournament Director's decision shall be final.
16. The entry fees for the Olympiad (including membership of the ICCA for 2002 for one person) shall be as follows:

Amateur:	US $ 100
Semi-professional:	US $ 250
Professional:	US $ 500

"Amateur": programmers who have no commercial interest in their program, and are not professional game programmers. Applications for amateur classification must supply information to justify their claim.

"Semi-professional": Any program submitted by an employee or associate from a games-programming company. The program's name must not be derived from or similar to a commercial product.

"Professional": A program whose name is the same as or derived from a commercial product.

Any entry received after August 7th will be subject to a penalty fee, doubling the above fees.

ACKNOWLEDGEMENT AND ACCESSIBILITY

H.J. van den Herik

Acknowledgement
As Editor-in-Chief of the *ICGA Journal*, may I express my gratitude to the Guest Editors, Guy Haworth and Ernst Heinz, for this special 'Ken Thompson' issue and to Guy for the idea.

Accessibility
ICGA Journal readers may be interested to know that information on our publications is available on the Internet. Our homepage can be reached by http://www.dcs.qmw.ac.uk/~icca/journal.htm

Since the old email address of the ICCA Maastricht has been reinstalled there are now two e-mail addresses of ICCA Maastricht: CS-ICCA-L@cs.unimaas.nl and icca@cs.unimaas.nl

A Japanese homepage can be reached by http://www.cs.inf.shizuoka.ac.jp/~iida/icga/

A complete list of all articles, notes, and literature reviews published in the *ICCA Journal* and the *ICGA Journal* is available on the Internet at http://www.dcs.qmw.ac.uk/~icca/ICCAJtoc.htm

COMPUTER GAMES 2002

J. Schaeffer[1]

Edmonton, Alberta, Canada

Following the success of CG'98 and CG'00 in Japan, the third biennial Computer Games conference will be held at the University of Alberta in Edmonton, Alberta, Canada, on July 25-July 27, 2002.

Topics of Interest
The conference has traditionally emphasized artificial intelligence in the classic board and card games. Some relevant topics include high-performance game-playing programs, new theoretical developments in game-related research, search algorithms, learning, using knowledge, data mining games databases, annotating games, etc.

CG'02 is expanding the conference scope to include artificial intelligence in commercial games. Some relevant topics include path finding, rule-based systems, finite state machines, learning, NPCs, game design, artificial life, etc.

Preliminary Deadlines
Submission Deadline April 1, 2002; Notification of Acceptance/Rejection May 1, 2002

Information available at http://www.cs.ualberta.ca/~games/CG2002

THE FIRST JENAZON CUP
ARBITRARY HUMAN+COMPUTER TEAMS IN AMAZONS

Ingo Althofer[2]

Jena, Germany

In some brain games top human players and top computer programs are approximately equal in playing strength. Probably *Amazons* belongs to this class. In such games a human-computer combination may be a strong team, especially when skills of man and machine are brought together in a synergistic way. To learn about the potential of a human+computer team in Amazons, I would like to run a contest (the Jenazon Cup) where each participant is a team with an arbitrary number of players and an arbitrary decision structure. So, any combination of humans, programs, and computers will be accepted and may choose freely its ways to achieving decisions.

An important external limitation is that games in the Jenazon Cup will have to be played in real time via internet. In the Jenazon Cup, Amazons is played on a 10x10 board with the standard starting position for the amazons. An introduction to this game may be found, for instance, on the webpage of Theo Tegos: www.cs.ualberta.ca/~tegos/amazons/index.html

The Cup will start at the beginning of November 2001. The whole event is to be finished well before Christmas 2001. Games are to be played on a game server in the internet, probably on GGS. For information on GGS, see www.neci.nj.nec.com/homepages/mic/ggsa/ggsa.html. The detailed announcement may be found at http://www.minet.uni-jena.de/www/fakultaet/iam/personen/althofer_e.html under *Jenazon Cup*. Registration is possible from now on, at the email address althofer@mipool.uni-jena.de. The registration deadline is 30 September, 2001. There is no starting fee. One thousand Euro will be the prize for the winning team. The referee is Ingo Althofer. Proposals and questions are welcome to althofer@mipool.uni-jena.de. Please, spread the announcement. A second Jenazon Cup is intended for November 2002.

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ICCA TREASURER'S REPORT FOR 2000

David Levy[1] *(with assistance from Don Beal)*

ICCA assets declined during 2000, due to lack of sponsorship income from events. At the end of 2000, the subscription lists showed 333 paid-up members worldwide: 97 in North America; 236 in Europe and elsewhere. This compares with 367 the year before.

Here is a statement of the 31 December 2000 financial position, plus a summary of the income and expenditures for 2000.

All figures are shown in US dollar equivalent rounded to hundreds, for simplicity of interpretation. (The ICCA holds some of its money in Dutch guilders, Canadian dollars and UK pounds.)

Held in bank accounts at 31 December 2000	36,100
Debts from 2000 still to be paid:	
- printing costs Vol.23 No.4	3,800
- secretarial support for editing the Journal	19,200
- ACC7/8 money held on behalf of University	200
- WMCC17 money owed to MSO	800
Subscriptions already received for 2001 (or later)	2,600
Net assets at 31 December 2000	9,500

Table 1: Financial position as of 31 December 2000. Figures are approximate and in US dollar equivalent.

This means the ICCA still retained at 31 December 2000 an accumulated surplus of approximately 9,500 dollars. This was 17,500 dollars down on the previous year, largely due to lack of sponsorship to cover the costs of secretarial support for editing the Journal.

The table below shows the major income and expenditure flows for 2000, and also, for comparison, the previous two years.

	2000 income	2000 spend	1999 income	1999 spend	1998 income	1998 spend
Subscription income	11,500		11,300		15,900	
Sale of back issues+ACC books	2,900		1,800		2,700	
Bank interest on deposits	800		800		900	
Journal printing and postage		13,500		15,800		19,000
Secretarial help with Journal		19,200		0		0
Other administration costs		1,000		3,000		800
Net income from events	0		12,500		0	
Net cash flow over year	−17,500		+7,600		−300	

Table 2: Income and expenditures from 1 January to 31 December 2000. Figures are approximate and in US dollar equivalent. 1999 and 1998 figures are also shown for comparison.

The 1999 and 1998 income and expenditure figures have to be interpreted taking into account the 1997 advance payment for secretarial production costs (shown as an exceptional item in 1997). The 1999 income and expenditure figures appear to show a profit. However, if the 1999 Journal production costs had not been paid in 1997, the loss (excess expenditure over income) would have been 15,000 dollars.

Overall, the ICCA was solvent at the end of 2000, but will not remain so during 2001 unless further income is obtained. ICCA costs, of which the largest item is secretarial support for editing the Journal, now exceed income from the membership by about 20,000 per year. The ICCA needs to find new sponsors.

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CALENDAR OF COMPUTER-GAMES EVENTS IN 2001-2003

August 13-19, 2001
The First Man-Machine match of the history of International Draughts (10×10), La Roche-sur-Yon, France. For more information: Nicolas Guibert. Email: ng@buggy-online.com.

August 18-23, 2001
The 18th World Microcomputer Chess Championship (WMCC) to be held in Maastricht, The Netherlands. For more information: David Levy and Jaap van den Herik. Http://www.cs.unimaas.nl/Olympiad.

August 18-23, 2001
The CMG 6th Computer Olympiad to be held in Maastricht, The Netherlands. For more information: Jaap van den Herik / Johanna Hellemons / Jos Uiterwijk. Http://www.cs.unimaas.nl/Olympiad.

August 20-22, 2001
Computer-Games Workshop 2001 to be held in Maastricht. For more information: Jos Uiterwijk. E-mail: uiterwijk@cs.unimaas.nl. Http://www.cs.unimaas.nl/Olympiad.

November 2001
The Fourth Computer World Championship in Renju and GoMoku, Moscow, Russia. For details contact Alexander Nosovsky. Email: stigma.ltd@relcom.ru. Http://www.www.japan-games.da.ru.

November 2001
The First Jenazon Cup Amazons Tournament. A two-months Internet Tournament of arbitrary human and computer teams. For details contact Ingo Althöfer. Email: althofer@mipool.uni-jena.de. Information available on http://www.minet.uni-jena.de/www/fakultaet/iam/personen/althofer_e.html

November 30-December 1, 2001
The 2nd annual European Game-On Conference on simulations and AI in Computer Games. For more information: Michael Allen, Email: ex1215@wlv.ac.uk. Http://hobbes.rug.ac.be/~scs/conf/gameon2001.

March 8-13, 2002
Special Session on Heuristic Search and Computer Game Playing at JCIS 2002. Paper submission by October 1, 2001. Email: chen@uncc.edu. For details contact Keh-Hsun Chen, Department of Computer Science, University of California at Charlotte, 9201 University City Boulevard, Charlotte, NC 28223-0001, USA.

May 14-17, 2002
The first International Workshop on Entertainment Computing (IWEC) to be held in Chiba, Japan. There are five topics, among which Computers and Games. Paper submission by December 15, 2001. Email: herik@cs.unimaas.nl; iida@cs.inf.shizuoka.ac.jp. For details contact Jaap van den Herik or Hiroyuki Iida, Department of Computer Science, University of Shizuoka, Hamamatsu 432-8011, Japan.

July 25-July 27, 2002
The Third Biennial Computer Games Conference (CG 2002), University of Alberta, Edmonton, Canada. For more information: Jonathan Schaeffer, Dept. of Computing Science, University of Alberta, Edmonton, Canada. Email: jonathan@cs.ualberta.ca. Information available on http://www.cs.ualberta.ca/~games/CG2002.html.

October/November, 2003
A World (Micro)computer Chess Championship in Graz. Details to be announced later. Contact persons: David Levy (Chair ICCA) and Professor Kurt Jungwirth (Chair Organising Committee).

THE SWEDISH RATING LIST

ICCA Communication
T. Karlsson

Continuing our policy, this issue contains the latest version of the Swedish Rating List. All games were played at 40 moves in two hours by members of the Swedish Chess Computer Association (SSDF). The '+' denotes the upward 95% confidence interval, the '–' denotes the downward 95% confidence interval on the rating, 'games' stands for the number of games on which the rating is based and 'against' stands for the average rating of opponents. By elementary methods wider (>95%) or narrower (<95%) confidence intervals may be derived by referring to Gaussian statistics.

#	Name	Rating	+	–	Games	Win %	against
1.	Deep Fritz 128MB K6-2 450 MHz	2653	29	28	647	64	2551
2.	Gambit Tiger 2.0 128 MB K6-2 450 MHz	2650	43	40	302	67	2528
3.	Chess Tiger 14.0 DOS 128MB K6-2 450 MHz	2632	43	40	308	67	2508
4.	Fritz 6.0 128MB K6-2 450 MHz	2623	23	23	968	64	2520
5.	Junior 6.0 128MB K6-2 450 MHz	2596	20	20	1230	62	2509
5.	Chess Tiger 12.0 DOS 128MB K6-2 450 MHz	2576	26	26	733	61	2499
7.	Fritz 5.32 128MB K6-2 450Mz	2551	25	25	804	58	2496
8.	Nimzo 7.32 128MB K6-2 450 MHz	2550	24	23	897	58	2491
9.	Nimzo 8.0 128MB K6-2 450	2542	28	28	612	54	2511
10.	Junior 5.0 128 B K6-2 450 MHz	2534	25	25	790	58	2478
11.	Gandalf 4.32f 128MB K6-2 450 MHz	2531	28	28	627	51	2524
12.	Hiarcs 7.32 128MB K6-2 450 MHz	2525	27	27	679	56	2482
13.	SOS 128MB K6-2 450 MHz	2521	22	22	1022	52	2508
14.	Hiarcs 7.01 128MB K6-2 450 MHz	2521	34	34	419	46	2550
15.	Rebel Century 3.0 128 MB K6-2 450 MHz	2518	30	30	546	49	2524
16.	Chessmaster 8000 128 MB K6-2 450 MHz	2502	50	52	191	42	2560
17.	Goliath Light 128MB K6-2 450 MHz	2497	28	28	628	44	2539
18.	Nimzo 99 128MB K6-2 450MHz	2489	24	24	826	49	2493
18.	Crafty 17.07/CB 128MB K6-2 450MHz	2487	24	24	857	47	2506
20.	Fritz 5.32 64MB P200 MMX	2478	18	18	1473	53	2455
21.	M_Chess Pro 8.0 128MB K6-2 450MHz	2477	29	30	557	43	2525
22.	Chessmaster 6000 64MB P200 MMX	2473	61	53	184	76	2278
23.	Hiarcs 7.32 64MB P200 MMX	2473	23	22	970	55	2435
24.	Fritz 5.0 PB29% 67MB P200 MMX	2459	23	22	1005	66	2342
25.	Hiarcs 7.0 64MB P200 MMX	2459	21	21	1112	55	2420
26.	Nimzo 99 64MB P200 MMX	2446	23	23	885	51	2439
27.	Junior 5.0 64MB P200 MMX	2432	19	20	1280	47	2454
28.	Nimzo 98 58MB P200 MMX	2426	21	21	1126	56	2380
29.	Rebel 9.0 47MB P200 MMX	2421	24	23	900	61	2342
30.	Hiarcs 6.0 49MB P200 MMX	2417	24	24	829	56	2373
31.	Rebel 8.0 51MB P200 MMX	2409	22	22	971	48	2424
32.	M_Chess Pro 6.0 41MB P200 MMX	2406	24	24	831	52	2393
33.	Shredder 2.0 58MB P200 MMX	2401	20	20	1242	46	2433
34.	M_Chess Pro 7.1 46 MB P200 MMX	2394	22	22	1042	53	2371
35.	Genius 5.0 DOS 46MB P200 MMX	2390	20	20	1177	50	2390
36.	M_Chess Pro 8.0 64MB P200 MMX	2390	27	27	681	53	2367
37.	Chess Tiger 11.8 Pentium 90 MHZ	2382	43	43	261	50	2383
38.	Gandalf 3.0 64MB P200 MMX	2364	41	40	307	59	2297
39.	Kallisto II 64MB P200 MMX	2343	35	35	403	52	2328
40.	Rebel 9.0 Pentium 90 MHz	2335	23	23	890	47	2356
41.	Junior 4.0 Pentium 90 MHz	2287	22	22	1035	42	2341
42.	Shredder 1.0 Pentium 90 Mhz	2282	59	58	145	53	2263
43.	R30 v. 2.5	2274	41	38	343	69	2135
44.	Meph Genius 68 030 33 MHz	2198	45	44	248	55	2161
45.	Berlin Pro 68 020 24 MHz	2125	24	24	850	58	2071
46.	Meph RISC 2 1 MB	2125	62	66	125	39	2205
47.	Mephisto Montreux ARM 14 MHz 512K	2099	29	28	689	73	1930
48.	Atlanta SH7000 20 MHz	2090	29	28	647	69	1949
49.	Sapphire II	2012	35	33	444	63	1916
50.	Milano Pro SH7000 20 MHz	1974	33	32	469	61	1895

As of January 1, 1996, the Swedish Rating List is no longer available to subscribers in printed form, though it will continue to be included in each issue of the Journal. Those wishing to obtain updated copies of the Swedish Rating List are invited to extract them by FTP via the SSDF's Homepage of the Internet, http://home3.swipnet.se/~w-36794/ssdf/

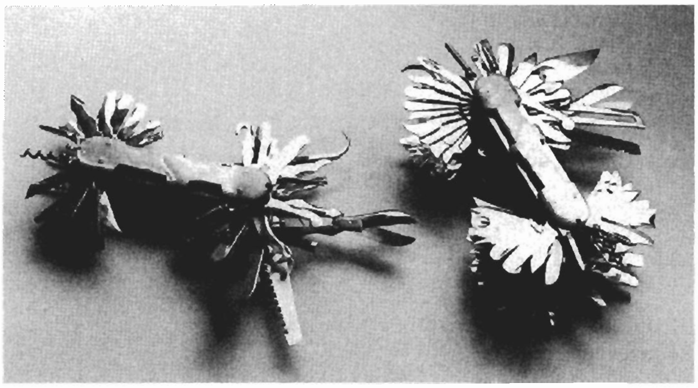
CLAUDE SHANNON (1916 – 2001): PERSONAL MEMORIES

Ben Mittman[1]

Evanston, IL USA

Much has been written about Claude Shannon since his death in February, including the obituaries that Ken Thompson and Jaap van den Herik contributed to the last issue of the *ICGA Journal*. I would like to add a few personal memories of a simple, brilliant and unassuming man of science and fun. Dr. Shannon was invited by the Board of the ICCA in September of 1980 to be our special guest at the 3rd World Computer Chess Championship in Linz, Austria. The year was the 30th anniversary of his seminal paper: *Programming a computer for playing chess*. In Linz Shannon set the ground rules quickly: "I don't do windows or give talks". That was fine with us since his mere presence, along with his lovely wife Betty, gave us inspiration and pleasure.

Three things stand out in my mind as characteristic of this eclectic genius: juggling, Swiss Army knives and the Sacher torte. Shannon's contributions to the art and theory of juggling have been reported widely. In Linz, he kept several of us enthralled with his scholarly and pragmatic discussions of his efforts to instrument a juggler with wired gloves and electronics to capture raw data that would subsequently enter into his mathematical theory of juggling.



Betty and Claude Shannon, Linz

Much less known is Claude Shannon's fascination with Swiss Army knives and other such "toys." Before arriving in Linz he had stopped in Germany to visit his instrument maker and to pick up two multi-tooled knives and two complex harmonicas. The Shannons invited me up to their room to view their new treasures. Sitting at a small round table, Claude began to unfurl (if that is the right word) these carefully crafted, two-spindled marvels. They opened like exotic flowers. We spent about an hour discussing the various elements, and finally Claude consented to pose for a few photos. I have saved them as unforgettable memories of a man who reveled in invention and in the exotic.

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Now for the Sacher torte. As the tournament was drawing to a close, and BELLE won a playoff with CHAOS to become the World Champion of 1980, Claude Shannon told us that he and Betty would be staying for a few days at the famous Sacher Hotel in Vienna, and he invited a number of us to join them there for dinner when we passed through Vienna on our way back to the States. Upon arriving at our own hotel (of course, numerous stars below the Sacher Hotel) we asked the desk clerk to make a reservation for nine at the Sacher Restaurant. He looked over the band of vagabonds that was checking in, and said in a somewhat haughty tone, "Zi restaurant vill not let you een – you must vear ties und jackets." For those of you who are familiar with the computer-chess community, you will realize how impossible such a constraint seemed at the moment. But after a quick inventory was made, we determined that, yes, we could all appear properly attired, and the reservation was made.

The dinner was sublime, the company was animated, and before breaking up Claude Shannon said that we must all come up to see their magnificent, 19th century bedroom. The outcome of that invitation became the most famous portrait of the leading pioneers in the field of computer chess (on some of whom one can find two of my jackets and three of my ties!). We can thank Claude Shannon and his wife Betty for giving us the chance to be all together in a such a wonderful setting – and, I seem to recall that we also ate Sacher torte for dessert.

Sacher Hotel, Vienna, September 1980

I personally will never forget the man who provided such solid theoretical structure to all of the computer chess programs that followed his fundamental paper of 1950. But, to tell the truth, I will remember him most as the warm and gracious person who brought such simple humanity to the Linz tournament and to all who met him during his long and fruitful life.

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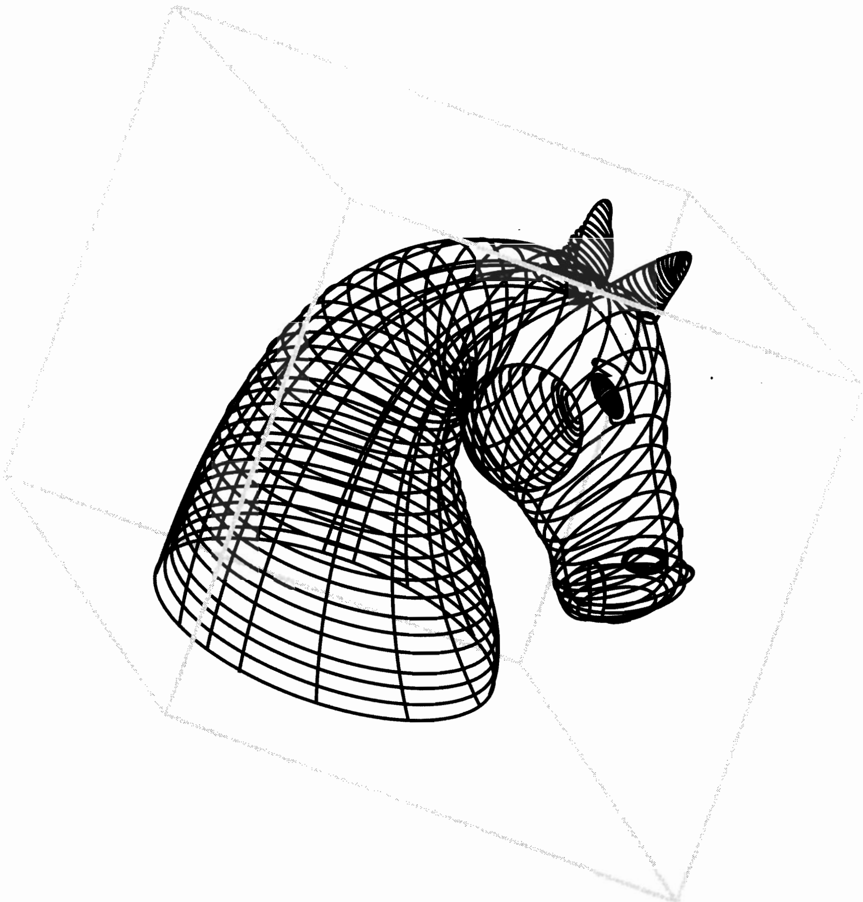

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