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# Conceptual Modelling for Requirements of Government to Citizen Service Provision

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**Abstract** Government to citizen (G2C) service provision is demanded to fit for purpose for users. A process of finding services from a G2C system involves understanding of the user's request, selecting the relevant services, and deciding amongst the candidate services to meet the user's needs. Some current approaches, such as benchmarking methods, are capable of measuring the service quality in the quantitative manner. However, G2C services also have intangible features which can be measured qualitatively. In this paper, a method is described to model the requirements of G2C services and their provision. To facilitate a service provision process, a set of criteria is identified and used to ensure the quality of the resultant services. An ontology model developed represents requirements of service provision in a web service environment that involves service consumers, service providers, and service advisor. Interactions between these stakeholders are defined by norms which generate workflows for executing the functions in the techniques. An experiment using DEA is carried out in this paper based on quantitative criteria to validate the method and its techniques, i.e. *articulates*, *derives* and *pre-selects*. The pre-selected services as the candidates are further evaluated with the contribution of the qualitative features of the services by using analytical hierarchical process (AHP) to decide for winning services.

## 1. Introduction

Government to citizen (G2C) service provision can be defined as an execution of public services to citizens (i.e. users) that involves various service providers

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through information and communication technologies (ICT) [2]. As the services become widely online available, the user is also becoming more demanding for fit for purpose services to be provided. This requires an effective approach to benchmark the quality of G2C services and assist in an optimisation process for a right choice of the service [18]. However, identifying a suitable service provided by a pool of providers needs an approach to recognise citizens' personalised needs and their needs change. This paper presents an ontology model with a set of techniques that enable a multi-criteria decision making process to provide fit for purpose services to meet citizen requirements in the e-government setting. This model incorporates citizen and service provider profiles which define citizen and service provision requirements. Norms are also built in the model to facilitate a systematic service selection and optimisation process.

The remainder of the paper is organised as follows. Section 2 discusses current trend in measuring quality of G2C service provision and also techniques that can be used in selecting the optimum service requested. Section 3 presents an ontology model with the embedded norm engine which facilitates the requirements analysis for service provision. Section 4 illustrates how the techniques in the ontology model are applied to assist the pre-selection of candidate services and optimise winning services. Section 5 draws conclusion and recommendations for the further work.

## **2. Related work**

### ***2.1 G2C service provision***

Currently, web service approach has been adopted by the G2C systems, e.g. DirectGov. Web services support three functions; service description and publishing, service discovery, and service interaction and consumption. Service providers are the ones responsible for publishing their services in the registry from which service consumers can locate and invoke services. The registry (or a public repository) is a public directory containing information about the services and the service providers from diverse sources in a unified way [20]. Web Service driven G2C systems can provide a seamless applications integration that allows the services to be loosely coupled and re-useable across organisational boundaries and from multiple providers via a public repository [17]. However, the current G2C systems are provider-centric by imposing G2C services to be passively provided to users [19]. There are demands for transferring the provider driven approach on to a citizen-centred approach. In a development of citizen driven G2C systems, services should be discovered to meet the user's needs. The traditional web service approach is, to certain extent, able to capture the user's requirements, but the service finding process lacks the capability of comprehensive selection and optimisation of the suitable services. Such capability can not be achieved by keywords matching and smart text mining for similarity, this requires a holistic domain

knowledge understanding and representation of G2C service provision. A service register in web services should act as a *service advisor* which applies the underpinning service provision strategies and criteria for service discovery.

The European Commission (EC) defines the G2C services into 12 areas; income taxes, job search, social security benefits, personal documents, car registration, application for building permission, declaration to the police, public libraries, birth & marriage certificates, enrolment in higher education, announcement of moving, and health-related services [5]. It is challenging that a G2C system accomplishes these service provisions via ICT [12], because the dynamic G2C interactivity with complete routine tasks can be sophisticated from both the service providers and users. There is lack of knowledge representation on how to advise quality services offered by the provider to the user. Quality of service in this work is defined through an ontological representation in meeting user needs who expresses a request in the context of higher education service provision. The work extends current e-Government benchmarking approaches by incorporating qualitative criteria in measuring service quality and applying the process of meeting user needs in a web-service environment.

## ***2.2 Service selection and ranking methods***

DEA is a linear programming algorithm that has been used successfully in determining the best-practice production frontier relative to individual firms or decision making units (DMUs). In DEA, performance efficiency is measured by a weighted sum of outputs to a weighted sum of inputs for a particular DMU [6][1]. A DMU represents a service provider who in a pre-selection stage is competitively measured against other providers on their overall performance based on a set of criteria that have been developed. A resultant efficiency,  $h_o$ , from DEA is normally decided by either maximizing outputs or minimizing inputs. In our work, maximizing outputs will be considered. DEA is capable of discovering those DMUs which hold a range of value of  $h_o$  based on the selection criteria. For those DMUs which satisfy  $h_o = 1$ , they need to be further decided as a winning DMU for the request. AHP, therefore, is used to assist for such decision making [1][15].

AHP is a multi-criteria decision making (ranking and optimising) algorithm which enables decision makers who are faced with making numerous and conflicting evaluations to derive a way to come to a compromise [3][4]. In a set of criteria, each criterion is assigned with significant attribute and each pair of alternatives can be judged by comparing between criteria. Once each comparison has been carried out through all the determining criteria, a winning DMU can be selected.

### 3. Modeling requirements of G2C service provision

G2C service provision is a knowledge sharing process which requires understanding and representation of the concerns of stakeholders (including users, service providers and service advisor) [11]. An ontological modelling [10] is adopted to define the patterns of behaviour in such a process where various agents with their roles and relationships are involved as well as the norms that govern the service provision workflow.

#### 3.1 Ontological modelling for the Requirements of Service Provision

An ontology model, as shown in Fig. 1, depicts the knowledge of G2C service provision. The model comprises of a set of semantic units, each of which is normally formed by the basic concepts of *agent*, *role*, *affordance*, and *determiner* [14][9]. An *agent* is drawn with a shape of an ellipse and represents a stakeholder such as an individual (person), a group (organisation) or a community (nation, society). *Affordance* is represented with a rectangle and depicts the relationships of entities and observable pattern of behaviour occurring within a context [10]. An *affordance* forms a semantic unit with a maximum of two antecedents (the concepts on the left end of the line) so as to maintain a concise and stable ontology structure. From the model then, different agents are involved in service provision with various roles such as *citizen*, *provider*, *service advisor* and *central government*, which represent responsibilities defined by the corresponding affordances.

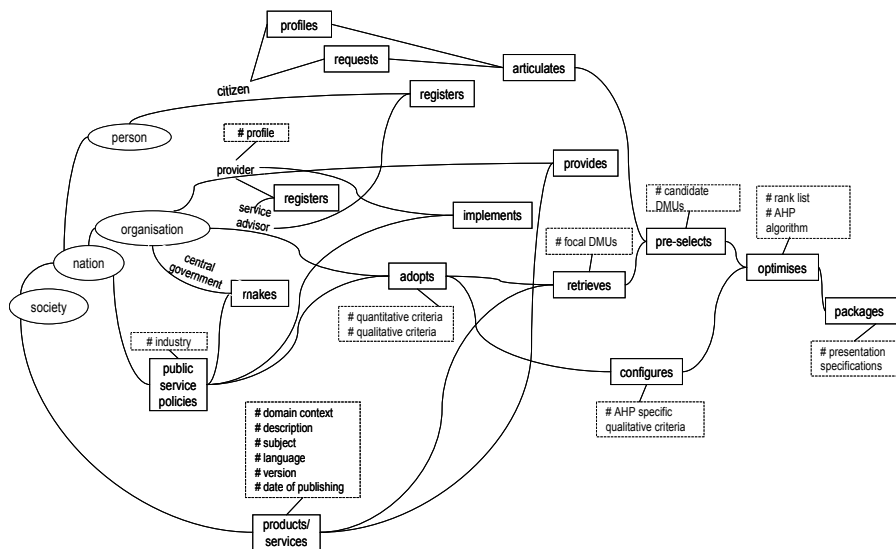


Fig. 1 An ontology model of G2C service provision

All these responsibilities have direct or indirect relations with *products/services* modelled in the ontology. For example, the affordance of *provides* has two antecedents, i.e. *organisation* and *products/services*. The antecedent of *products/services* describes the type of G2C provision and the *organisation* with the role of *provider* provides the G2C services. This semantic unit ensures the service being provided complies with the *public service policies* made by the government. With the affordance of *retrieves*, there are two antecedents of *adopts* and *products/services*. The antecedent of *adopts* defines the quantitative and qualitative criteria based on *public service policies* for a particular *industry* that are adopted by the *organisation* in the role of *service advisor*. The antecedent of *adopts* ensures that there is no conflict of attributes in the *retrieves* process. For example, in universities, sponsorships are available for full-time postgraduate courses only. This therefore resolves conflicts concerning criteria for *course duration*, *mode of study* and *finance*. The *retrieves* process then contains the focal DMUs with their capabilities in service provision described by the quantitative and qualitative criteria that are defined from adopting the *public service policies*. So, in order to provide a personalised service/product, the model pays special attention to the quality of service provision based on service specification which involves articulation of *requests* of service and citizen's *profile* leading into a pre-selection process with *retrieves*.

The ontology model therefore integrates the requirements for user, service provider, and service advisor with the defined role of *citizen*, *provider* and *service advisor* respectively. Each registered *citizen* has a *profile* which is used to articulate a request for services made to *service advisor*, particularly if the request is fuzzy. For example, if a *citizen* requests for a service of course in Higher Education and this user has some degree of disability. In this case, personal information in the citizen profile will assist to specify the requirements specifications for selecting the service which meets the user's needs. The affordance of *pre-selects* is the one that performs the selection process, and it is ontologically dependant on *articulates* and *retrieves* – the former specifying citizen's request, the latter the DMUs and their capabilities in providing the *services*.

### 3.2 Criteria for measuring the quality of services

The quality of service is largely determined by the service provider who has the reputed capability and competence to offer their services. In order to benchmark service providers for their performance and capability, each registered service provider is described in a provider's profile (see Fig. 2). The *profile* contains the details of a service provider and involves units which provide services. A *Portfolio* describes the capability of the service provision and the quality of the service meeting users' demands. *Provider\_profile* assists an identification of focal DMUs while a service provider is being benchmarked in a pre-selection process. This profile also possesses the measures for finding candidate services according to a service request. Table 1 details the service quality measures in the form of criteria.

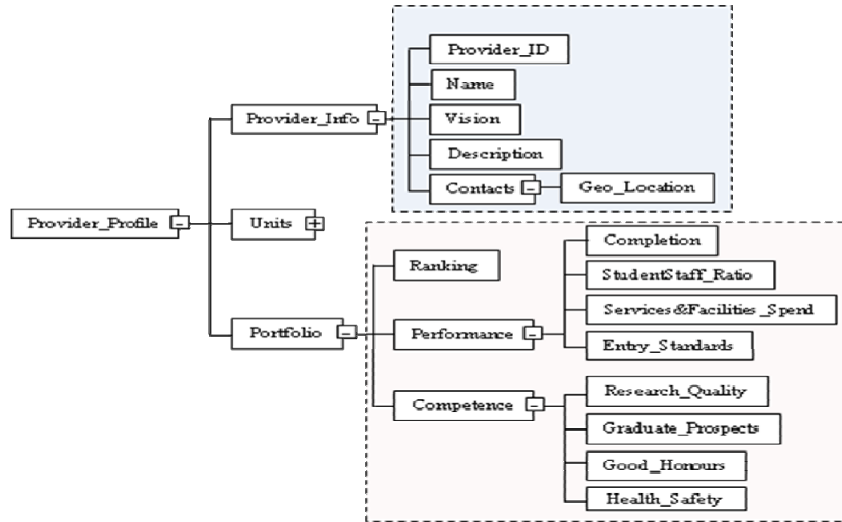


Fig. 2 Service provider profile

A service schema in Fig. 3 defines the features and properties of the concept of *products/services* in the ontology model. This schema also captures the criteria in Table 1 for assessing a service. Those service specific criteria can be used to benchmark the quality of the services in conjunction with the provider specific criteria. A set of metadata, such as domain context, description, and language can assist a discovery of the products/services.

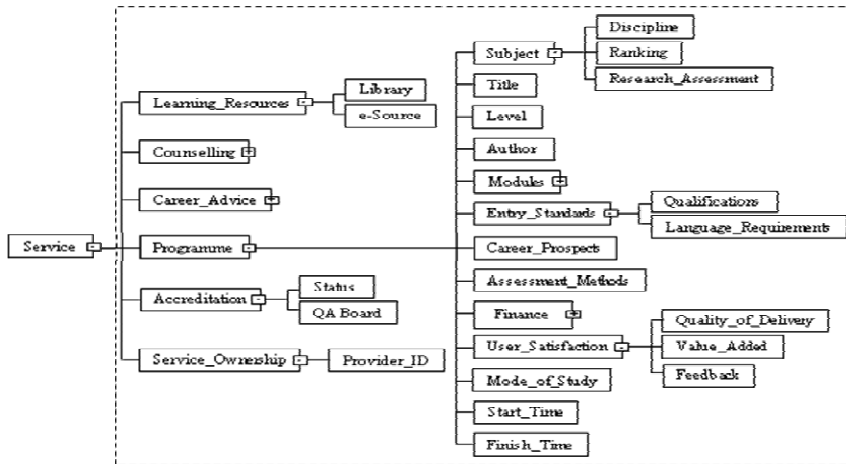


Fig. 3 Service Schema



**Table 1** Criteria for selecting the relevant *service*

Criteria	Sub-criteria	Type	Description
Quality	Provider ranking	Quantitative	Overall performance
	Subject ranking	Quantitative	Subject performance
	Quality of delivery	Quantitative	Student views on the teaching quality of the subject
	Research assessment	Quantitative	Research quality and innovation
	Entry standards	Quantitative	Requirements for admission of a subject
	Career prospects	Qualitative	Job opportunities and positions for graduates
	Graduate prospects	Quantitative	Destinations of subject graduates
	Student-staff-ratio	Quantitative	Average staffing level for the subject
	Good honours	Quantitative	Percentage of graduates achieving a first or upper second
	Alumni	Qualitative	Experience of graduates
	Accreditation	Qualitative	Reviewed status of institution quality by authorities
	Assessment methods	Qualitative	Ways by which learning outcomes being assessed
	Value added	Quantitative	Student level of achievement from the course
	Feedback	Quantitative	Student judgement of quality of subject they have studied
Disability services	Qualitative	Means by which various disabilities can be supported	
Finance	Academic service spend	Quantitative	Expenditure per student on all academic services
	Facilities spend	Quantitative	Expenditure per student on staff and student facilities
	Tuition	Quantitative	Monetary value to studying the program per academic year
	Financial support	Qualitative	Bursary, sponsorships and funding for the course
Flexibility	Mode of study	Quantitative	Full-time/part-time/distance learning
	Academic calendar	Quantitative	Different starting dates of the course
Geog. Location	Country	Quantitative	The country where the service is offered

### 3.3 Norms defining the service provision process

In order to systematically perform a service provision process, norm engine acts as a control mechanism to govern the behaviour of cause of actions. In the ontology model, each affordance of the semantic unit is associated with a period of existence which can be defined by a pair of *startNorm* and *finishNorm*. During the existence, *operationalNorm* describes its pattern of behaviour. For

```

<?xml version="1.0" encoding="UTF-8"?>
<Norm_pre-selects>
<StartNorm ID=N1.1>
  <whenever> a citizen requests a service via a service advisor </whenever>
  <if_condition> the services AND the quantitative criteria can be retrieved</if_condition>
  <then_agent> pre-selects engine </then_agent>
  <is_deontic_operator> permitted </is_deontic_operator>
  <to_action> execute the pre-selection workflow </to_action>
</StartNorm>
<finishNorm ID=N1.2>
  <whenever> a citizen requests a service via a service advisor </whenever>
  <if_condition> the services AND the existing quantitative criteria can no longer be found
</if_condition>
  <then_agent> pre-selects engine </then_agent>
  <is_deontic_operator> obliged </is_deontic_operator>
  <to_action> cease the pre-selection workflow </to_action>
</finishNorm>
<operationalNorm ID=N1.3>
  <whenever> a citizen requests a service via a service advisor </whenever>
  <if_condition> the service specific & provider specific criteria are available AND the request is
clearly articulated </if_condition>
  <then_agent> pre-selects engine </then_agent>
  <is_deontic_operator> obliged </is_deontic_operator>
  <to_action> select AND rank all the DMUs whose  $h_0=1$  by using DEA algorithm:

      
$$\text{Max } h_0 = \frac{\sum_r u_r y_{r0}}{\sum_i v_i x_{i0}} \quad | \quad \sum_i v_i x_{ij} = 1 \quad \sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0 \quad | \quad j = 1, 2, \dots, n \quad | \quad u_r, v_i \geq 0$$


  </to_action>
</operationalNorm>
</Norm_pre-selects>

```

**Fig. 4** The norms defining the *pre-selects* process

example, the *startNorm* and *finishNorm* define the *pre-selects* existence and its cease (see Fig. 4). The *operationalNorm* specifies the DEA algorithm that takes multiple input and multiple output quantitative criteria for selecting all competitive DMUs based on their maximum efficiencies, i.e.  $h_0=1$ . The operational norms are normally defined for generating a workflow of each affordance in the semantic unit. The result from the left semantic unit is carried over as the input to the workflow in the right semantic unit. All the workflows can be integrated to structure the entire service provision process.

#### 4. Application and discussion of the ontology model

The ontology model and the techniques are validated through various simulations towards the selected service requests. A service selection process normally starts from a service request. For example, a *person* with the role of *citizen* requesting for a higher education programme, e.g. a master course in Computer Science from a top 10 university in the UK that starts from October and also offers studentships. Based on the request, the *articulates* deduces a set of multiple criteria of {*Geo\_Location*, *Ranking*, *Graduate\_Prospect*, *Entry\_Standards*, *Good\_Honours*, *Completion*} from the provider's profile as well as {*Title*, *Ranking*, *En-*

try\_Standards, Career\_Prospect, Graduate\_Prospect, Financial\_Support, Level, Start\_Time, Quality\_of\_Delivery, Value\_Added, Feedback} from the service schema. Each of these criteria is assigned with a weight which is determined by the requestor’s preference in conjunction with the pre-defined domain rules. The *pre-selects* then uses the criteria to discover the DMUs. There are two sets of results produced to represent the quality of the service on the basis of institutional and subject level respectively (see Table 2 and Table 3). The results in Table 2

**Table 2** The consolidated results for the DMUs based on provider rankings

DMU	INPUT		OUTPUT					
	Provider Ranking	Entry Standards	Completion	Good Honours	W/O	W/I	Efficiency	Working
INS-037	5	0.4732	1.0000	0.7990	0.9699	1.0000	0.9699	-0.0301
INS-085	3	0.5045	1.0000	0.7062	0.8960	1.0000	0.8960	-0.1040
INS-118	9	0.4588	1.0000	0.7823	0.9871	1.0000	0.9871	-0.0129
INS-133	1	0.5346	1.0000	0.9296	0.9561	1.0000	0.9561	-0.0439
INS-222	7	0.4978	1.0000	0.9053	1.0000	1.0000	1.0000	0.0000
INS-366	4	0.5031	1.0000	0.7917	0.9069	1.0000	0.9069	-0.0931
INS-424	2	0.5439	1.0000	0.8788	0.8973	1.0000	0.8973	-0.1027
INS-522	6	0.4823	1.0000	0.8302	0.9752	1.0000	0.9752	-0.0248
INS-847	10	0.4521	1.0000	0.7802	1.0000	1.0000	1.0000	0.0000
INS-975	8	0.4914	1.0000	0.8739	0.9896	1.0000	0.9896	-0.0104

show that only INS-222 and INS-847 satisfy the maximum efficiency, i.e.  $h_o=1$  and also fall into top 10 institutional ranking [7][8] that primarily meet the user’s request. The *working* column shows the difference between weighted output (W/O) and weighted input (W/I) as constraint derived from,  $\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \leq 0$ , where  $j=1,2,\dots,n$  and  $u_r, v_i \geq 0$ . The results in Table 3

**Table 3** The consolidated results for the DMUs based on subject rankings

DMU	Subject Ranking	Provider Ranking	Entry Standards	Quality of Delivery	Value Added	Feedback	Graduate Prospects	Efficiency
INS-037	31	5	0.4614	0.7500	0.0341	0.4659	1.0000	1.0000
INS-085	7	3	0.4915	0.8723	0.0319	0.6277	1.0000	1.0000
INS-118	18	9	0.5256	0.9634	0.0610	0.7073	1.0000	0.9838
INS-133	1	1	0.9566	0.9566	0.0361	0.6831	1.0000	0.9222
INS-222	2	7	0.4915	0.9314	0.0704	0.6651	1.0000	1.0000
INS-424	3	2	0.6359	0.9565	0.0217	0.8152	1.0000	1.0000
INS-522	5	6	0.5554	1.0000	0.0482	0.7952	1.0000	1.0000
INS-847	8	10	0.4943	1.0000	0.0455	0.5114	0.9091	0.8754
INS-975	26	8	0.5063	0.8750	0.0500	0.6625	1.0000	1.0000

present the subject quality measures independently from the general performance of the institutions. It is observed that a subject ranking position many not be the same as its provider's. By comparing these two sets of results, it is expected to identify a discrepancy, particularly when there is no link between them at all.

Based on the subject ranking, 6 out of 9 institutions satisfy the maximum efficiency with INS-222 achieving the maximum efficiency in both provider and subject rankings. The two sets of results suggest 1) getting an optimum result based on the subject of interest from the pre-selected institutions, i.e. INS-037, INS-085, INS-222, INS-424, INS-522 and INS-975; 2) considering the institution which has been pre-selected in both cases, i.e. INS-222; or 3) getting an optimum result based on the pre-selected institutional rankings. To follow the third suggestion which is the original user request, the list of the candidate DMUs produced by *pre-selects* is further analysed for optimisation. The affordance of *optimises* determines the winning service by using the AHP algorithm with specific qualitative criteria, i.e. *Financial\_Support*, *Career\_Prospects*, *Provider\_Ranking* and *Subject\_Ranking*. Fig. 5 represents the decision tree for multi-criteria evaluation. In

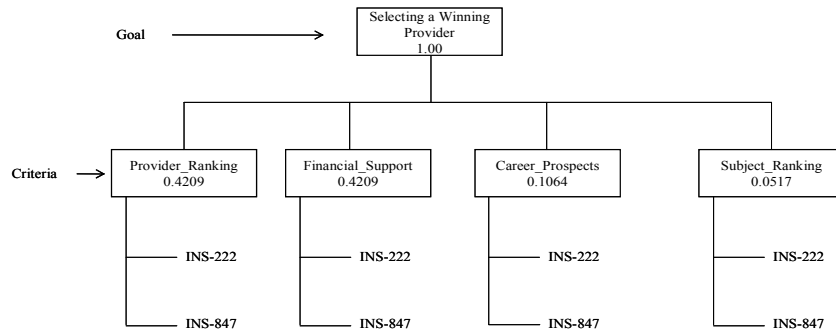


Fig. 5. The decision tree with the criteria weights

order to ensure a consistency in prioritisation, consistence ratio  $CR = CI/RI$  is computed.  $CI$  represents consistency index,  $\lambda_{\max} - n/n$ , where  $\lambda_{\max}$  is the principal eigen value,  $n$  is the number of pair-wise comparison matrix, and  $RI$  is Random consistency Index. In this simulation,  $CR = 2.72\%$  shows that the preferences for 4 criteria are consistently evaluated, i.e.  $CR \leq 10\%$  [13][16]. Due to the user request, *Provider\_Ranking* and *Financial\_Support* are assigned more weights.

AHP computation shows that *Subject\_Ranking* has very little significance (i.e. 0.0517) compared to the others. Therefore, it was ignored in the further computation. Consequently, the weights for the other three criteria have to be re-adjusted, such as 0.4439 for *Provider\_Ranking*, 0.4439 for *Financial\_Support*, and 0.1122 for *Career\_Prospects*. Table 4 consolidates the overall composite weights of the two DMUs and INS-222 satisfies the user's request.

**Table 4** Overall composite weights of the alternatives

	Provider Ranking	Financial Support	Career Prospects	Composite Weight	Rank
Adjusted Weights	0.4439	0.4439	0.1122	1.0000	
INS-222	0.8333	0.2500	0.5000	0.5370	1
INS-847	0.1667	0.7500	0.5000	0.4630	2

## 5. Conclusion and future work

G2C service provision presents a complex problem domain that demands a method to model requirements of service provision. This research work has proposed the use of ontology model for conceptualising the domain knowledge where citizen requirements are presented from the aspect of social domain. The ontology model presents very well the concept of web service with different stakeholders such as *service advisor*, *central government*, and *service providers* interacting to ensure that quality of G2C service provision is maintained. Profiles were also created to facilitate articulation of *requests* and to support for *personalised* service provision. Service schema was developed to illustrate different attributes and criteria for the service provided. Norms were embedded in the model for the execution of a pre-selection workflow. DEA has been applied to implement *pre-selects* process due to the multi-criteria nature of the problem domain which also exhibits multiple output and multiple input service criteria. The results indicate that DEA has been effective in selecting suitable services that can meet citizen request.

The model also provides for alternative suggestions to the user to capture intentions and what can also be provided in line with the user request which the user might not be aware. This forms the intelligent part of the system which calls for further work. To process further the request from pre-selection, an evaluation was conducted to compare the differences between the needed qualitative criteria of the selected service providers. AHP was used as a mechanism to prioritise the selected services based on weighting and the optimum service candidate capable of meeting citizen requirements was identified. Future works will also need to identify mechanism to assist the selection in the problem domain through matching cases, and to develop a CASE tool to facilitate consistent documentation.

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