An Ontology-Based Architecture for Consumer Support Systems

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Abstract

For enterprises, customer relationships have been commonly recognized as a critical factor to succeed their business. Effective customer relationships could help enterprises deliver services to customers based on their needs, preferences, or past transactions. This model however emphasizes on the use of customer information for benefiting enterprises; customers in contrast receive less information from enterprises. To address this issue, a new paradigm, namely Consumer Support Systems (CSS) is initiated to support effective information provision for customers to help on their decision making. In this paper, we present an ontology-based architecture for such a new CSS paradigm. The architecture starts from the identification of CSS characteristics, through the recognition of architectural components that support the realization of these issues, and finally ends with the specification of collaborations among architectural components to realize these issues. In particular, for those inherent integration issues in CSS, it imposes semantic ontologies on the specifications to facilitate integration among customers and enterprises. The architecture is modeled by UML and illustrated by a CSS for travel arrangement.

Keywords: customer relationship management, consumer support system, ontology-based, architecture, UML

1 Introduction

For enterprises, customer relationships have been commonly recognized as a critical factor to succeed their business. Effective customer relationships could help enterprises deliver services to customers based on their needs, preferences, or past transactions. In this context, many strategic/technical discussions have been presented: (1) Customer Decision Support (CDS) [1,2]; (2) Customer Relationship Management (CRM) [3-6]; (3) Customer Knowledge Management (CKM) [7-13]; (4) Recommendation System [14-16]; and (5) Intelligent Agent [17,18]. In general, these approaches focus on the use of customer information for benefiting enterprises; their usefulness on enhancing customer relationships has already been demonstrated [7]. Nonetheless, several limitations or shortcomings can still be found:

1. CDS does not address the compiling (e.g., extracting or filtering) of services info. from various enterprises; customers often receive massive and unstructured info. and hence be difficult on their decision making.
2. CRM does not capture truly valuable customer information due to its focusing customer knowledge on previous transactions [11]. Also, it focuses on individual enterprises and hence is not effective on collecting services info. from multiple enterprises.
3. CKM emphasizes on truly valuable customer info. by capturing knowledge from customers (i.e., residing in themselves). However, as in CRM, it addresses on individual enterprises and hence is not effective on delivering services information from various enterprises to customers.
4. Recommendation System delivers services info. from multiple enterprises to customers based on their preferences. However, as in CRM, it relies primarily on past transactions and thus is difficult to catch what customers really need by capturing truly valuable customer information.
5. Intelligent Agent serves individual customers based on their detailed information. However, as in CDS, it does not support the compiling of services info. from various enterprises for an effective aid on the decision making process of individual customers.

In addition, from the viewpoint of information flow, these approaches emphasize on collecting customer info. for enterprises (i.e., capturing knowledge about/from customers for enterprises) where the reverse delivery of information (i.e., receiving services info. from enterprises to benefit customers) is somehow insufficient. This presents a notable problem of information asymmetry that hurdles customer relationships since customers have no sufficient services information to assist on their decision making about what they really need. To address this problem, a new Consumer Support Systems (CSS) paradigm has been introduced [19] that is structured by a 4-layer framework of collaborative mechanisms to support effective information provision from enterprises to customers. Under its framework, many technical/strategic solutions about the customer decision support can be employed as those in [20-26]. Therefore, there are already many approaches about the structural, strategic, or functional issues for CSS. For its development, nonetheless, any considerations on its architecture and characteristics to provide guidance on its construction are still missing. Such development methods, however, should not be negligible since in our view sound methods are critical for directing the construction of such new CSS applications.

Thus, we present in this paper an ontology-based architecture for CSS that emphasizes on delivering structured services information from enterprises to customers based on their needs (e.g., knowledge) to help on their decision making. The architecture starts from the identification of CSS characteristics, through the recognition of architectural components that support the realization of these characteristics, and finally ends with the specification of collaborations among architectural components to realize these characteristics. In particular, for those inherent integration issues in CSS (e.g., information sharing among different customers or services provision from various enterprises), it imposes semantic ontologies on the specifications to facilitate integration among customers and enterprises. The architecture is modeled by UML [27,28] and illustrated by a CSS for travel arrangement.

This paper is organized as follows. Section 2 presents first our architecture that results in the creation of two UML diagrams, including component and sequence ones. The semantic ontologies imposed on the architecture are then presented in Section 3 where customer information is illustrated for easy sharing among customers. For illustration, the architecture is applied in Section 4 to the CSS for travel arrangement. Finally, Section 5 has the conclusions and our future work.

2 The architecture

Our architecture elaborates on the following three steps with UML utilized as its modeling tool:

1. **Characteristics identification** that considers those issues to be concerned for CSS and then identifies possible specifics to address these issues.
2. **Architectural identification** with a component diagram that determines architectural components to support the realization of identified CSS characteristics.
3. **Collaboration Specification** with a sequence diagram that specifies collaborations among architectural components to realize desired CSS characteristics.

2.1 Characteristics identification

The first step is to identify those characteristics in CSS. Initially, considering the functionality in CSS [19], the following issues about CSS should be concerned:

1. Effective services info. from various enterprises is needed to support consumer decision making. The information should be structured and easily comprehended. Also, it needs to be comparative for any desired attributes of these services to aid on the analysis and decision making by consumers.
2. To make services info. useful for consumers, referencing truly valuable consumer knowledge [11] to capture what consumers really need must be supported for enterprises. In general, capturing knowledge from consumers (i.e., residing in themselves) is trust-sensitive, and hence should be served by some independent and reliable agents or organizations (i.e., consumer knowledge agents).
3. Consumers usually make requests for their needs by issuing desired tasks (e.g., buying services) in accordance with their knowledge or characteristics. These tasks lead to their awareness of desired service attributes which in turn results in the search, recognition, and comparisons of available services that exhibit those attributes. To aid on such desired tasks, some task-centered services are required to act as an intermediary between enterprises and consumers. For enterprises, these services help to capture knowledge from consumers (related to their desired tasks) to provide services info. useful for these consumers. For consumers, these services help to collect and evaluate task-desired services info. from various enterprises, and then present to them for their possible recognition and comparisons. As in above, for reliability, such services should be provided by some independent/reliable marketplaces or organizations (i.e., task service providers).
4. Consumer communities [29-31] are helpful for consumers to share or co-learn information about their desired tasks. It is therefore usually organizing consumers into various communities by their common interests or personal characteristics. Each community relates consumers to their desired tasks for sharing or exchanging information among each other. In addition, each community could provide them with such services as identification and recommendation around cooperative task service providers, and negotiation and cooperation with those service providers selected by them to process their task requests (i.e., return evaluated services information relevant to these requests). In general, communities are the last intermediary between consumers and the outside world, and thus are usually supported by some independent/ reliable marketplaces or organizations.

To address these issues, the following specifics about CSS can then be identified:

1. Consumers may enroll into communities where they are able to share or co-learn information about their desired tasks for services.
2. Such shared or co-learned information is then re-structured by some consumer knowledge agents into appropriate styles of consumer knowledge which will be captured by enterprises (via task service providers) to provide services info useful for these consumers.

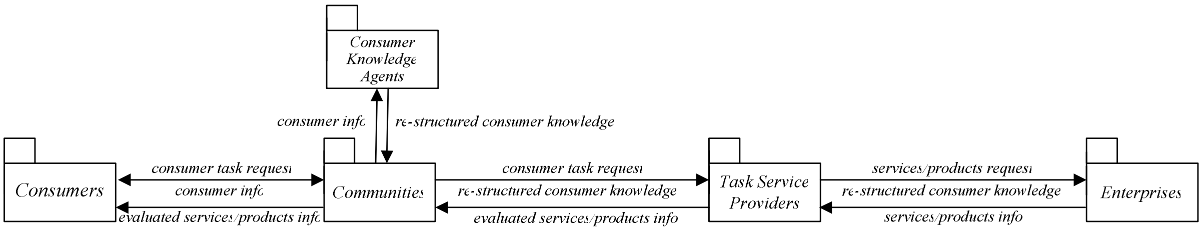

Figure 1 the architecture for semantic consumer support system

3. Through identification and recommendation by communities, consumers select task service providers to which their task requests are issued (as a common recognition, consumers usually issue task requests based on info. they homogeneously share or co-learn among each other); communities then negotiate and cooperate with these providers to accomplish these issued task requests.
4. Based upon requests received, task service providers help to collect, structure, and evaluate information about task-desired services from various enterprises, and then present (via communities) to consumers for their possible recognition and comparisons.
5. Since task requests lead consumers to be aware of desired service attributes, the structured and evaluated services information makes them be able to recognize and compare available services that exhibit those attributes.

As a result, CSS has the characteristics to be possessed as follows.

1. It is structured into a 4-layer architecture of collaborative mechanisms (i.e., five architectural components as shown in Figure 1) where ***consumers*** are no longer interacting directly with ***enterprises***, but via three intermediaries: ***communities***, ***consumer knowledge agents***, and ***task service providers***.
2. It emphasizes on communities to help consumers share or co-learn information about their desired tasks **(so homogeneity among info. by various consumers is required for its sharing or co-learning)**.
3. It emphasizes on truly valuable customer info. by collecting knowledge from consumers (i.e., residing in themselves) to help enterprises catch their needs **(so homogeneity among knowledge from various consumers is required for its being captured)**.
4. It addresses on delivering structured services information from multiple enterprises to help customers make recognition and comparisons **(so homogeneity among services info. from multiple enterprises is required for its being recognized and compared)**.
5. It emphasizes on delivering services information based on requests from consumers **(so matching of requests with services info. is required for figuring out desired part)**.

2.2 The architecture identification

Based on these characteristics and relevant specifics about CSS mentioned above, CSS can be designed as shown in Fig. 1 to address them by the interactions between consumers and enterprises through three intermediaries. The following presents how these five components play their designated roles in CSS.

(1) Consumers

In CSS, consumers may make requests for their needs by issuing desired tasks (e.g., buying services) in accordance with their knowledge or characteristics. To enhance their knowledge about these tasks, they may enroll into various communities through which to share or co-learn information among each other. With such shared or co-learned information, consumers may get more awareness of desired service attributes relevant to their tasks. After issuing task requests (via communities), consumers expect to receive information about available services that exhibits those attributes. In particular, before presenting to consumers, the services information should be collected (by task service providers) from various enterprises, and then structured and evaluated (in terms of desired service attributes) to aid consumers on their analysis and decision making.

In summary, these characteristics need to be possessed as the requirements for the *Consumers* component:

1. **access consumer info. –** help to interact with consumers to access information that is shared or co-learned among each other (***through communities in a homogeneous manner***).
2. **issue task request -** help to interact with consumers to issue task requests (***after referencing shared or co- learned info.***), and then present desired task-relevant services info.

Based on the above requirements for the *Consumers* component, Figure 2 shows its constituents that collaborate to achieve its responsibilities. As shown in the figure, three constituents are imposed where (1) the two 'Info. manager' and 'Task request manager'

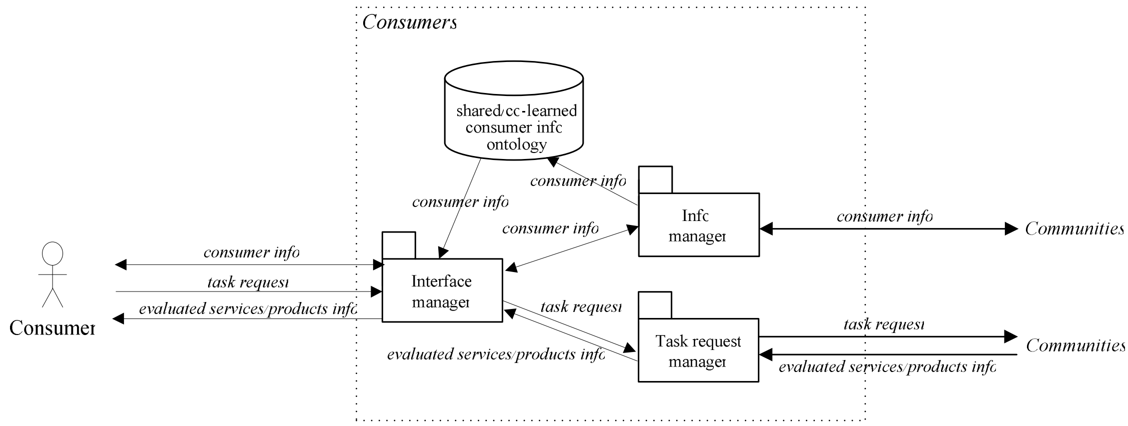

Figure 2 the *Consumers* component for consumer support system

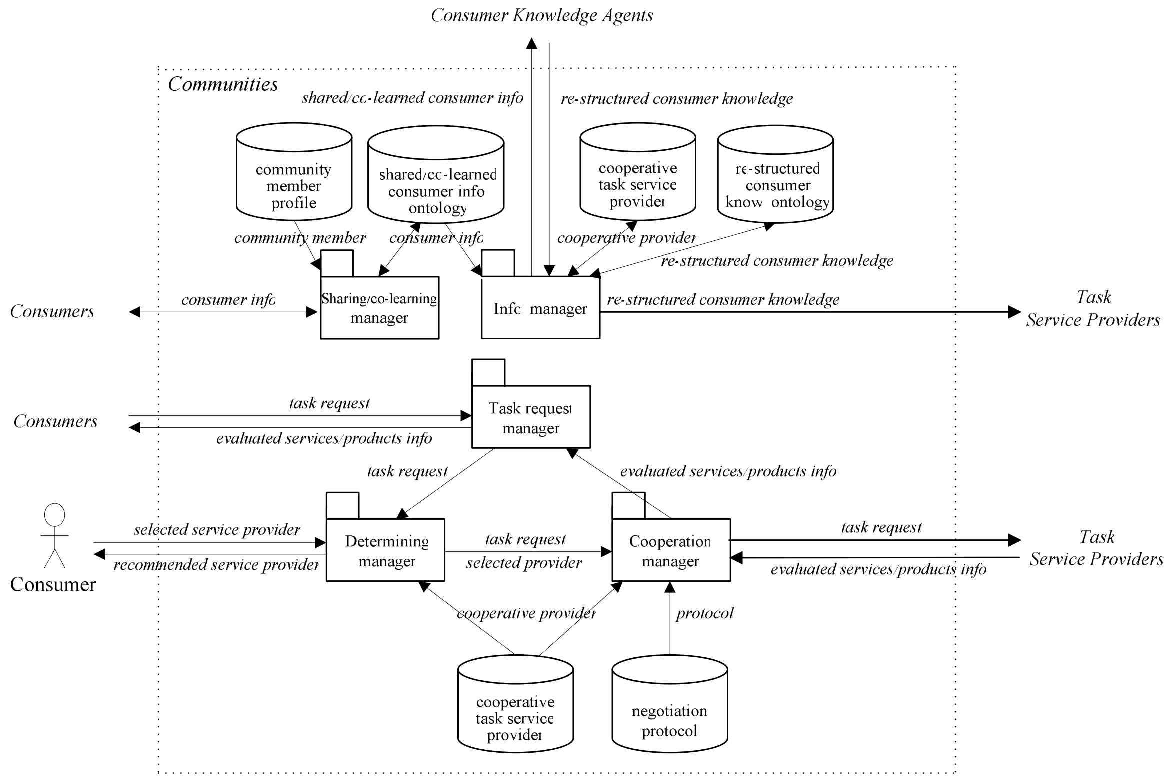

Figure 3 the *Communities* component for consumer support system

constituents are responsible respectively for realizing the two requirements; and (2) the 'Interface manager' constituent is employed to assist the interaction with consumers to access their shared or co-learned information and task requests, and then present their desired task-relevant services information. In particular, the 'shared/co-learned consumer info.' ontology is used to provide formal descriptions of the information referenced before issuing task requests.

(2) Communities

Communities are organized for consumers to share or co-learn their info. about their desired tasks or interested services. Consumers may enroll into various communities within which those with common interests or personal characteristics are grouped together for information sharing or exchanging. Also, communities are also responsible for forwarding such shared or co-learned information to some consumer knowledge agents that re-structure it into appropriate styles of consumer knowledge. Communities then forward the knowledge to cooperative task service providers that will in turn pass it to enterprises for capturing what consumers really need. Finally, communities also provide consumers with such services as identification and recommendation of cooperative task service providers that are capable of accomplishing their task requests, and negotiation and cooperation with those service providers selected by them to actually accomplish these requests.

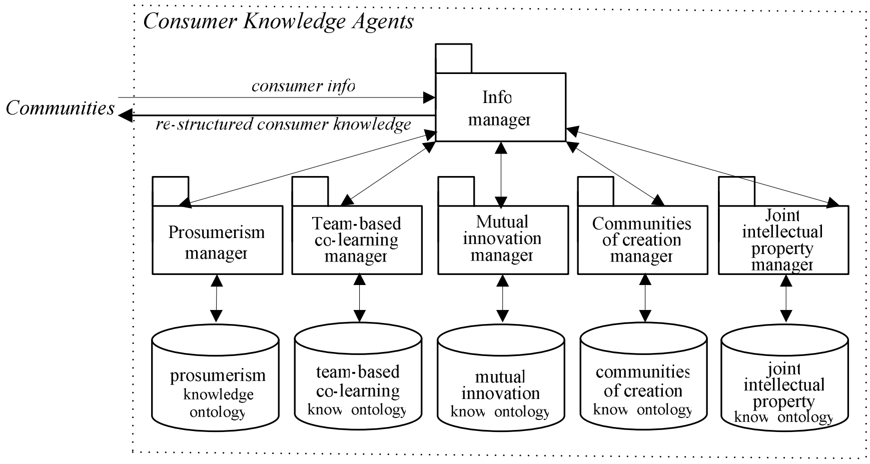

Figure 4: the *Consumer Knowledge Agents* component for consumer support system

In summary, these characteristics need to be possessed as the requirements for the *Communities* component:

1. **share/co-learn consumer info. –** help on info. sharing or co-learning among consumers (***homogeneity among info. needs to be ensured***).
2. **process shared/co-learned info. –** forward shared/ co-learned info. to consumer knowledge agents that return re-structured knowledge, and then forward the knowledge to cooperative task service providers (***homogeneity among knowledge needs ensured***).
3. **process task request -** receive task requests from and return desired task-relevant services information to consumers.
4. **determine task service provider** - identify and recommend cooperative task service providers to be selected by consumers.
5. **cooperate with task service provider -** negotiate and cooperate with those service providers selected by consumers that actually accomplish task requests by returning evaluated services information relevant to these requests.

Based on the above requirements for the *Communities* component, Figure 3 shows its five constituents that realize respectively the five requirements. In particular, the 'Sharing/co-learning manager' constituent accesses a 'shared/ co-learned consumer info.' ontology for homogeneously sharing or co-learning info. among interested consumers; while the 'Info. manager' constituent accesses it to retrieve shared or co-learned info. for re-structuring into comprehensible knowledge by consumer knowledge agents (a 're-structured consumer know.' ontology is employed to ensure its homogeneity). Further, the 'Determining manager' constituent accesses the 'cooperative task service provider' file to identify and recommend cooperative task service providers to be selected by consumers, while the 'Cooperation manager' constituent accesses it to negotiate and cooperate with those service providers selected by consumers that actually accomplish task requests by returning evaluated services info.

(3) Consumer Knowledge Agents

In CSS, information from consumers is critical for enterprises to capture what they really need in order to provide services information truly useful for them. However, such information may initially be unstructured and even, after sharing or co-learning among consumers, complex for usefulness. It is therefore necessary to have a specific mechanism that is responsible for re-structuring it into various comprehensible styles of knowledge (i.e., the five styles of knowledge defined in [11] where information from consumers can be attributed into one or more of these five styles of knowledge) for enterprises to capture what these consumers really need. For this requirement, consumer knowledge agents are imposed to re-structure consumer info. into these comprehensible styles of knowledge.

In summary, these characteristics need to be possessed as the following two requirements for the *Consumer Knowledge Agents* component:

1. **process consumer info.** – identify the style(s) of knowledge (i.e., the five styles of knowledge defined in [11]) into which consumer info. is categorized to capture valuable knowledge from consumers
2. **make five styles of consumer knowledge -** re-structure consumer information into appropriate style(s) of knowledge

Based on these two requirements, Figure 4 shows the constituents that collaborate to achieve its responsibilities. As shown in the figure, six constituents are imposed to realize the two requirements. In particular, each of the lower five constituents is imposed to access a style-specific knowledge ontology to homogeneously make the corresponding style of consumer knowledge based on the received shared/co-learned consumer information.

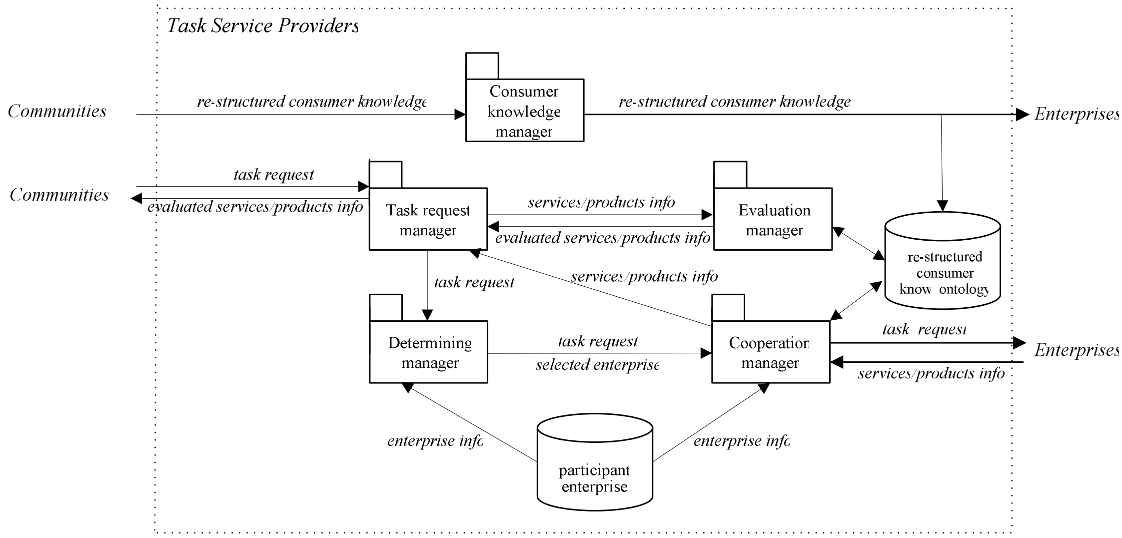

Figure 5 the *Task Service Providers* component for consumer support system

(4) Task Service Providers

Task service providers are an important intermediary between enterprises and consumers. For enterprises, they receive re-structured consumer knowledge from communities and, based on the task-relevant extent, forward the task-relevant part of that knowledge to the participant enterprises that utilize it to provide services information useful for consumers. For consumers, based on the task requests received from communities, they identify and cooperate with those participant enterprises that may provide services information desired by these task requests. Furthermore, with the information about task-desired services, they also help to structure and evaluate it in a comprehensive and comparative model that is then presented to consumers (via communities) to aid on their analysis and decision making.

Thus, these characteristics need to be possessed as the following requirements for the *Task Service Providers*:

1. **process consumer knowledge -** receive re-structured consumer knowledge from communities and forward the task-relevant part of the knowledge to participant enterprises.
2. **process task request -** receive task requests from and return evaluated task-desired services info. to communities.
3. **determine participant enterprise –** identify and select participant enterprises that may provide services information desired by task requests.
4. **cooperate with participant enterprise -** negotiate and cooperate with those selected enterprises to actually provide desired task-relevant services info.
5. **evaluate services info. -** structure and evaluate into a comprehensive and comparative model task-relevant services information provided by selected participant enterprises (***based on the re-structured consumer knowledge received above***).

Based on these five requirements, Figure 5 shows the constituents that collaborate to achieve its responsibilities. As shown in the figure, five constituents are imposed to realize respectively these requirements. Particularly, the 'Determining manager' constituent accesses the 'participant enterprise' file to determine those participant enterprises that may provide services/ information desired by task requests, while the 'Cooperation manager' constituent accesses it to negotiate cooperation with those selected participant enterprises to provide desired task-relevant services info. Note that the 're-structured consumer knowledge' ontology is used to evaluate the most suitable part of services information that is desired by consumers' requests.

(5) Enterprises

Enterprises that participate in CSS may respond to consumer task requests from task service providers with information about services that exhibits those attributes desired in these requests. As mentioned above, to make the info. truly useful for consumers, enterprises need to reference the re-structured consumer knowledge received from task service providers in the extent of those tasks requested by these consumers.

In summary, these characteristics need to be possessed as the requirements for the *Enterprises* component:

1. **process consumer knowledge –** store re-structured consumer knowledge for references to provide info. truly useful for consumers.
2. **accomplish task request -** based on the consumer knowledge, accomplish task requests by returning task-desired services information (***tasks requests are matched with services info. for figuring out task-desired services info.***).

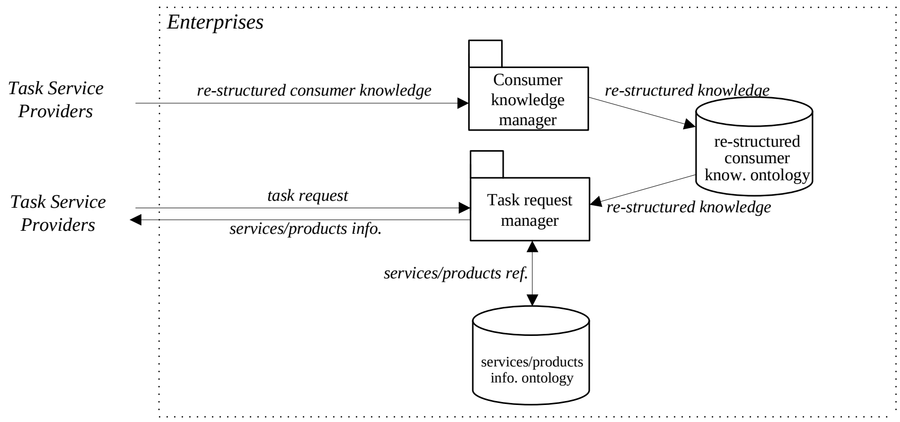

Figure 6: the *Enterprises* component for consumer support system

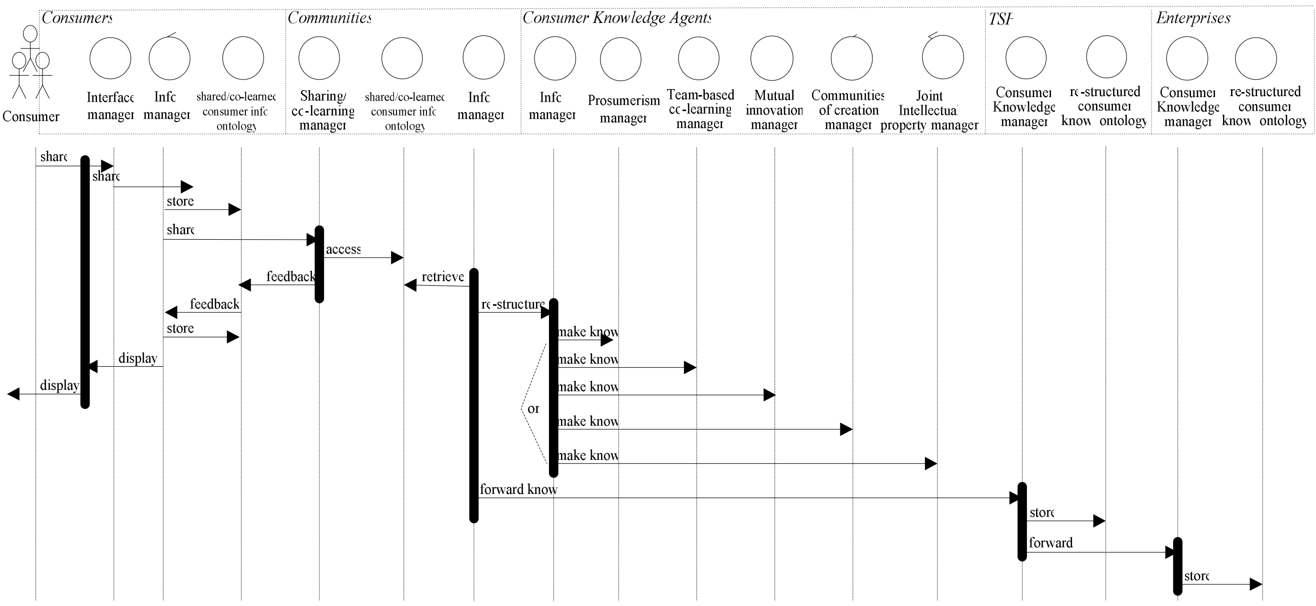

Figure 7.a: the sequence diagram for consumer info./knowledge management

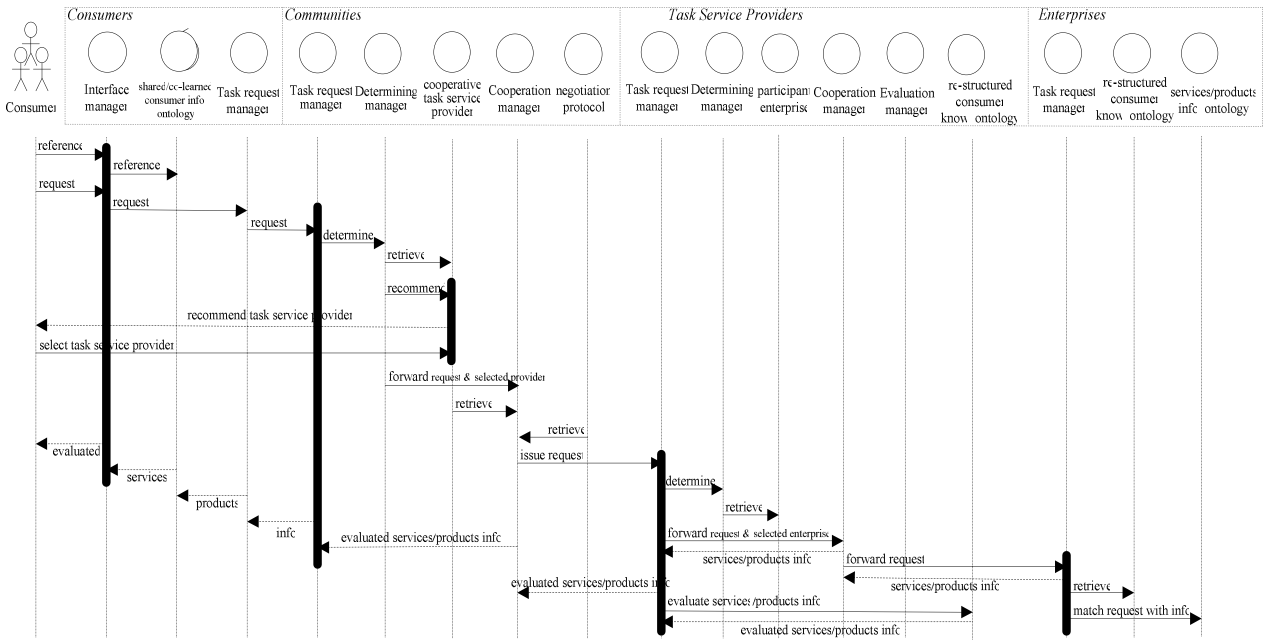

Figure 7.b: the object sequence diagram for service provision of consumer task request

Based on the above requirements for the *Enterprises* component, Figure 6 shows its respective constituents that realize the two requirements. Particularly, the 'Consumer knowledge manager' constituent accesses the 're-structured consumer know.' ontology to store re-structured knowledge of consumers on which info. about those services requested by these consumers is decisively based. Also note that the 'services info.' ontology is used to specify available services info. by which its matching with requests can be completed.

2.3 The collaboration specification

With architectural components identified, it is now good time to create a sequence diagram that specifies how such components collaborate to realize desired requirements. As illustrated in Figure 7.a, while a consumer tries to share his/her information through the system, both of the *Consumers* and *Communities* components collaborate to help his/her homogeneously sharing or co-learning purpose with other consumers by accessing all shared/co-learned info. from the 'shared/co-learned consumer info.' ontology. The shared/co-learned info. is then re-structured into comprehensible knowledge by the *Consumer Knowledge Agents* component that is in turn forwarded to the *Enterprises* component (i.e., the participant enterprises) via the *Task Service Providers* component (i.e., the cooperative task service providers). Finally, the *Enterprises* component stores the re-structured knowledge in the 're-structured consumer know.' ontology on which information about those services requested by consumers is decisively based. In addition, as illustrated in Figure 7.b, after referencing shared/ co-learned info., a consumer may request a task through the system. This makes both of the *Consumers* and *Communities* components collaborate to determine which task service providers are cooperative for him/her to process the request. With a selection by the consumer, the *Communities* component forwards the request to the *Task Service Providers* component (i.e., the selected task service providers). After determining participant enterprises, the *Task Service Providers* component forwards then the request to these enterprises (i.e., the *Enterprises* component) that return desirable task-relevant services info. (i.e., retrieving from the 'services info.' ontology based on the consumer knowledge stored in the 're-structured consumer know.' ontology).

3. Semantic ontologies for integration

After identifying architectural components and their collaborations for achieving behavioral requirements, it is then important to impose technical mechanisms on relevant components that alleviate those inherent integration difficulties in CSS (e.g., 'shared/co-learned consumer info.' ontology for homogeneous info. sharing/co-learning among different customers or 'services/products info.' ontology for homogeneous recognition and comparison of services provided from various enterprises). Among all possible endeavors, in our best knowledge, semantic ontologies are the most well-known approach for this consideration: (1) as a pristine way for knowledge-sharing, ontologies make descriptions of customer information (e.g., about experiences or requests) or enterprise services easy understood; and (2) ontologies make the matching of customer requests with enterprise services easy undertaken.

Therefore, we present herein an ontology that describes customer information for CSS. (It is noted that the ontology for enterprise services can be constructed in a similar way and the matching of customer requests with enterprise services can be easily achieved by applying the approach in [32]). To illustrate, the ontology is applied in a CSS for travel arrangement. It should be noticed that the ontology is expressed in our convenient distinguishable notations; although there are already many tools for describing ontologies [32,34,35], we do not concern herein the notational comparisons between our work and these existing tools.

3.1 The ontology

For constructing ontologies, the well-known approach in [33] can be followed with seven phases:

1. **determining domain and scope of the ontology**.
2. **considering reusing existing ontologies**.
3. **enumerating important terms in the ontology**.
4. **defining the classes and the class hierarchy**.
5. **defining the properties of classes - slots**.
6. **defining the facets of slots**.
7. **creating instances of classes**.

For illustration, Figure 8 shows an ontology constructed for travel arrangement where a hierarchical structure of classes are shown for describing representative concepts in travel arrangement. The properties and instances of classes are also illustratively presented for describing what instances each class has and what properties each class instance possesses or connects to other class instances.

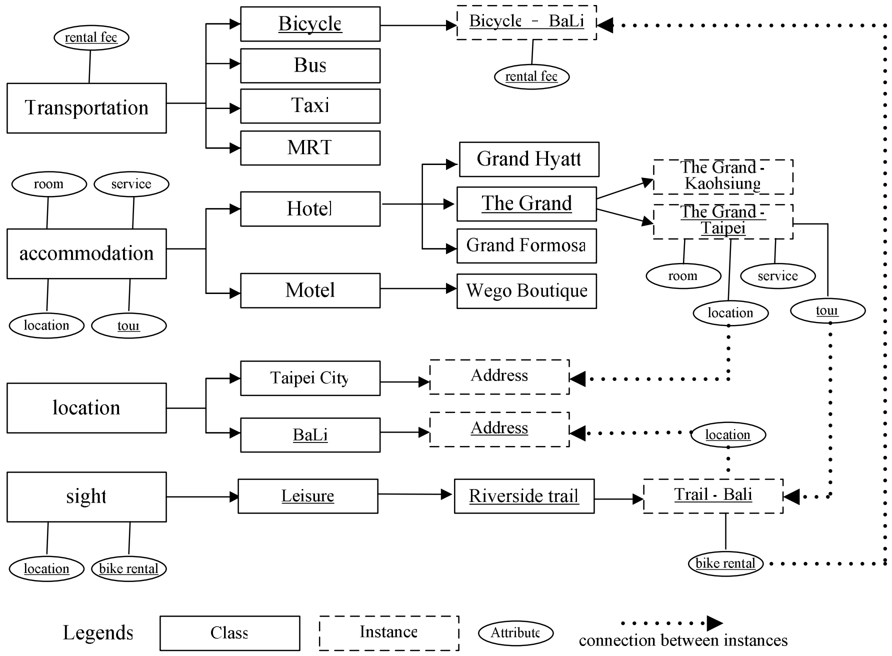

Figure 8 the conceptual classes and their properties and instances for travel arrangement

3.2 Applying the ontology while making requests

In this section, we illustrate the usefulness of the ontology created above by making customer requests based on its easy understood structure.

customer requests for travel arrangement

In our example, each customer may desire some services about travel arrangement after sharing or learning related experiences from other members in specific travel communities. For instance, he/she may desire to have a travel with the following arrangement: *The travel is accommodated at the Grand hotel in Taipei that arranges a tour for biking along riverside trail around the BaLi township*. Once such a desire is identified, a formal request for satisfying it can then be made based on the ontology as shown in Figure 9.

In our best knowledge, with this formal customer request, its being satisfied by possible enterprise services can be simply identified in an automatic manner in case these services and their instances and properties are specified also in ontologies (e.g., traversing the service ontology to ensure each desired instance or property in the request is matched with a corresponding component in the service ontology). With such mechanisms that specify customer information/requests and enterprise services by ontologies, and that ensure matches between them by automatic ways, CSS could provide customers with enhanced supports on (1) participating in various communities for sharing or co-learning information about their experiences or requests on enterprises; and (2) ensuring matches of their requests with enterprise services where they make final selections to satisfy these requests.

4. Applying to a CSS for travel arrangement

Providing customers with services about travel arrangement is very important for travel agencies. Many existing agencies offer relevant services such as searching, viewing, and ordering tours via their own web sites or intermediary agents (e.g., EzTravel). However, these ordinary functions are not sufficient for many customers who desire more sophisticated services (e.g., knowledge-based decision support) for their advanced purposes such as arranging new tours after sharing and learning related experiences with other customers. For these limits, we present in this section how such knowledge-based decision support functions can be realized in our method.

4.1 The requirements for travel arrangement

In our example, possible prospective customers like travelers may desire sophisticated knowledge-based decision support services about travel arrangement after sharing and learning related experiences with other colleagues. Therefore, four functions below are often necessary to satisfy their needs.

1. ***share travel experiences***: a traveler shares travel experiences with other travelers.
2. ***share tour site thoughts***: a traveler shares tour site thoughts with other travelers.
3. ***arrange a new travel***: a traveler arranges a new travel by organizing its transportation, accommodation, and tour sites.
4. ***recommend a new tour site***: a traveler recommends a new tour site by specifying its specialties.

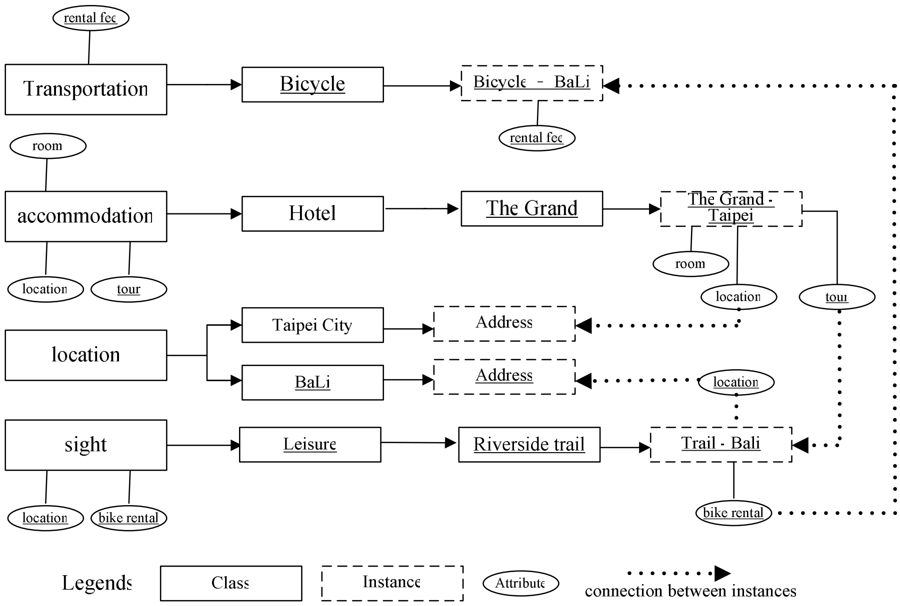

Figure 9 a request for travel arrangement

With knowledge-based functions, the following specifics about CSS for travel arrangement can be identified:

1. **The traveler and other interested ones** may enroll into **a travel community** where they are able to share or co-learn experiences about their travel arrangement purposes.
2. These shared or co-learned experiences can be re-structured by **a traveler knowledge agent** into certain style(s) of knowledge to be captured by **a travel agent** (via **a travel service provider** in the travel arrangement extent) that provides travel arrangement information useful for these travelers.
3. Through identification and recommendation by **the travel community**, **the traveler** issues a travel arrangement request to **a travel service provider** selected by him/her, and **the travel community** is then responsible for negotiation and cooperation with **the travel service provider** to accomplish this issued travel arrangement task.

Based upon the travel arrangement request, **the travel service provider** helps to collect, structure and evaluate information about travel arrangement from **the travel agent** that is then presented (via **the travel community**) to **the traveler** for his/her recognition and comparisons. Since the travel arrangement request can lead **the traveler** to be aware of desired travel arrangement attributes (e.g., transportation, accommodation, and tour sites of a travel), the structured and evaluated information about travel arrangement makes him/her be able to recognize and compare available travel arrangement services by **the travel agent** that exhibit those attributes.

As a result, CSS for travel arrangement has the following characteristics to be possessed.

1. It is structured into a 4-layer of collaborative mechanisms (i.e., five architectural components) where ***a traveler*** is no longer interacting directly with ***a travel agent***, but through such intermediaries as ***a travel community, a traveler knowledge agent,*** and ***a travel service provider***.
2. It emphasizes on collecting experiences/thoughts about travel arrangement by helping travelers to share or co-learn them among each other and then re-structuring them into certain style(s) of knowledge for **the travel agent** to catch **the traveler**'s needs.
3. It addresses on delivering structured information about travel arrangement from **the travel agent** to help **the traveler** to make possible recognition and comparisons.

Based on these characteristics and relevant specifics mentioned above, CSS for travel arrangement is thus designed as shown in Figure 10 to support interactions between **the traveler** and **the travel agent** via three intermediaries.

4.2 The CSS architecture for travel arrangement

In CSS for travel arrangement, a traveler issues a travel arrangement request via a travel community to acquire from a travel agent information about travel arrangement that is collected and evaluated by his/her selected travel service provider. In particular, bi-directional information flows between the traveler and the travel agent where (1) experiences/thoughts shared or co-learned among the traveler and other colleagues in the community is re-structured into various styles of traveler knowledge to be collected by the travel agent (via the travel service provider), and

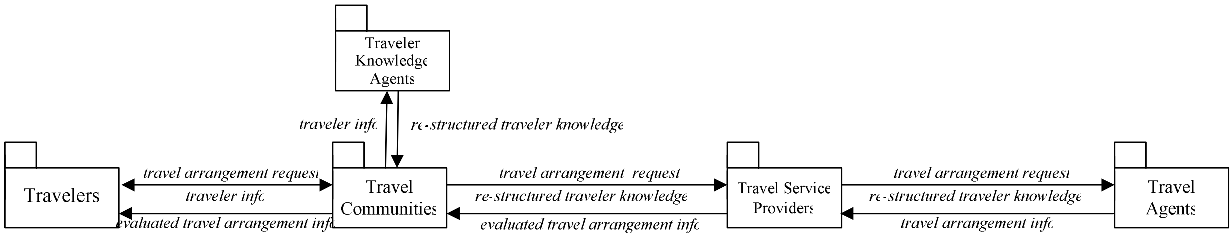

Figure 10: the CSS architecture for travel arrangement

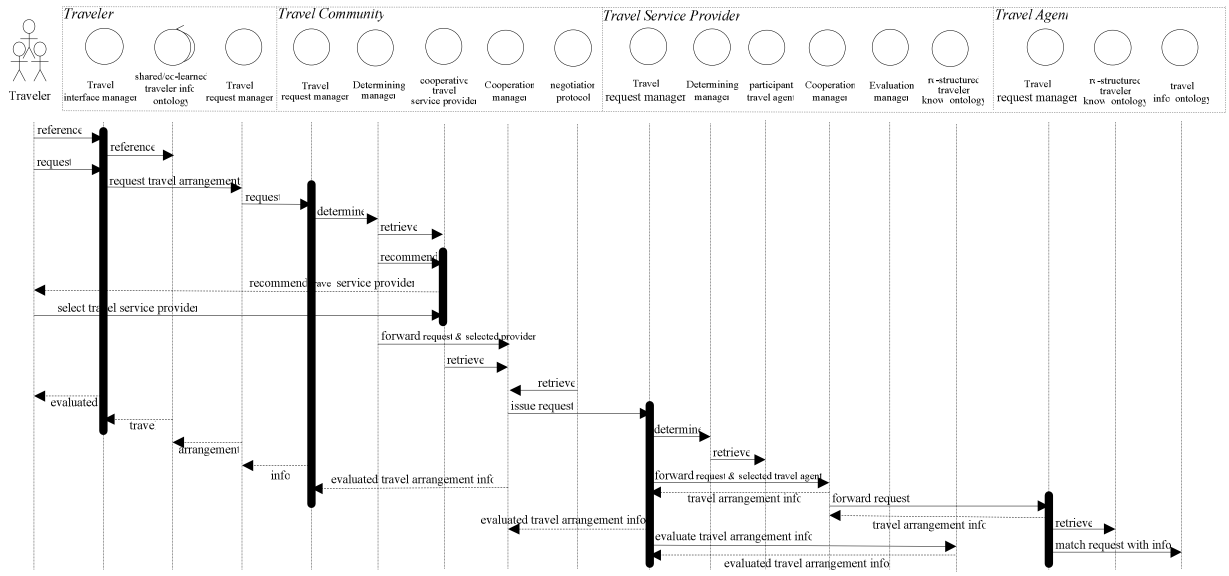

Figure 11: the sequence diagram for service provision of travel arrangement request

(2) along the reversed way, information about travel arrangement from the travel agent is structured and evaluated by the travel service provider for possible recognition and comparisons (via the community) by the traveler. Therefore, based on the generic CSS architecture in Figure 1, Figure 10 shows the CSS architecture for travel arrangement with five components (note that as one may conceive, these components would have the same constituents as those among Figures 2 – 6).

4.3 modeling behavior by the sequence diagram

With components identified, it is now good time to create a sequence diagram that specifies how such components collaborate to realize the traveler's needs. As illustrated in Figure 11, after referencing info. shared or co-learned with other colleagues (i.e., referencing the 'shared/co-learned traveler info.' ontology that stores homogeneous info. shared or co-learned among interested travelers), the traveler submits a travel arrangement request through the system; both of the *Traveler* and *Travel Community* components collaborate then to determine which travel service providers are cooperative for him/her to process the request. With a selection by the traveler, the *Travel Community* component forwards the request to the *Travel Service Provider* component (i.e., the selected travel service provider). After determining a participant travel agent, the *Travel Service Provider* component forwards the request to the agent (i.e., the *Travel Agent* component) that returns desirable information about travel arrangement based on the re-structured traveler knowledge (i.e., retrieving the traveler's knowledge stored in the 're-structured traveler know.' ontology to determine the most suitable part of information about travel arrangement that matches his/her request).

5 conclusions and future work

In this paper, we present an architecture for CSS where it addresses first on the identification of CSS characteristics. After identifying characteristics, the architectural components for CSS are then specified to support the realization of these characteristics. For CSS, these components focus on supporting both of the information from consumers to enterprises (i.e., for enterprises, capturing knowledge from consumers) and the reverse delivery of information from enterprises to consumers (i.e., for consumers, receiving services information from enterprises). In particular, for addressing such integration issues in CSS as sharing/co-learning information among different consumers and evaluating services information from multiple enterprises, it employs an ontology in CSS that illustratively describes customer information with an easy understood structure. (It is noted that the ontology for enterprise services can be shown in a similar manner and the matching of customer requests with enterprise services will be explored in our future work.) For a CSS with such a formal ontology, customers could get enhanced supports on (1) participating in various communities for sharing or co-learning information about their experiences or requests on enterprises; and (2) ensuring matches of their requests with enterprise services where they make final selections to satisfy these requests. In our best knowledge, this makes CSS good for enhancing customer relationships by providing effective supports on their decision making that is usually accomplished through such steps as information gathering, request making, and service ensuring.

For illustration, our method is applied to the development of a CSS for travel arrangement. Information about travel arrangement is shared or co-learned among travelers before they issue travel arrangement requests to travel agents. The shared or co-learned information is specifically re-structured into various styles of traveler knowledge on which information provided by these travel agents is decisively based. After then, whenever the traveler submits a travel arrangement request, the CSS could help him/her recognize and compare information from travel agents by structuring and evaluating the information before presenting it to him/her.

In general, many existing approaches to enhance customer relationships have been discussed; they emphasize mainly on the information from customers to enterprises where the reverse delivery of information is somehow insufficient, and hence results in a notable problem of information asymmetry that hurdles their effectiveness. For this situation, CSS is structured in recent years to support an effective bi-directional information flow between consumers and enterprises. For such a new CSS paradigm, nonetheless, any considerations on its architectural and behavioral characteristics to provide guidance on its construction are still missing. Such considerations, however, should not be negligible since in our view sound methods are critical for directing its construction. Our work presents a possible discussion on this subject.

As our future work, we will continue to explore the construction of the ontology for enterprise services and also the matching between request and service ontologies (e.g., applying the approach in [32] that traverses the service ontology to ensure each desired instance or property in the request ontology is matched with a corresponding component in the service ontology). As one may conceive, this complete work makes CSS good for enhancing customer relationships by providing effective supports on their decision making that is usually accomplished through such steps as information gathering, request making, and service ensuring. Thereafter, in addition to travel arrangement, we will look also forward to the practical use of our work in other domains like executive information systems; its usability on such decision support systems will also be carefully experienced.

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