Service Description: A survey of the general nature of services*

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Abstract

A proper understanding of the general nature, potential and obligations of electronic services may be achieved by examining existing commercial services in detail. The everyday services that surround us, and the ways in which we engage with them, are the result of social and economic interaction that has taken place over a long period of time. Any attempt to provide electronic services to people that does not take this history into account will fail. Any attempt to provide automated electronic services that ignores this history will deny consumers the opportunity to negotiate and refine over a large range of issues, the specific details of the actual service to be provided. To succeed at the latter, we require a rich and accurate representation for the properties of services.

Properties of services that may be visible and variable include (1) the method of charging, of mutual settlement obligations, of payment; (2) the channels by which the service is provided; (3) spatial and temporal availability; and (4) service quality and security. We also provide a service lifecycle which attempts to view the service from the provider's viewpoint: market awareness, conception, advertisement, provisioning and from the consumer's viewpoint: need recognition, discovery, negotiation, invocation and payment. This paper builds on an understanding of services and their lifecycle to outline these properties and the challenges faced in their representation. Accurate descriptions are integral to meaningful discovery, composition and management of services.

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1 Introduction

Services are ubiquitous. We encounter them in our everyday life and more recently they have become an electronic business integration enabler. No standard currently exists that is capable of accurately representing services. The need to describe a service is analogous with the requirement for labelling goods or products. Product labels provide a summary description of the good to which it is attached. Prospective buyers use the information, together with the price, to make a rational decision about purchasing the product. The label on a jar of pasta sauce may contain the product name, the type of sauce, the manufacturer's name, their address, the ingredients, a bar code, an expiry date, a date of manufacture or batch number, directions for use, benefits or drawbacks (i.e. nutritional information), customer feedback details (e.g. a phone number) and possibly even examples for use (e.g. a recipe). Product labelling occurs for the safety and benefit of purchasers. Why is the same labelling requirement not afforded for the benefit of service requestors?

Inadequate description triggers questions for a requestor. When you encounter a service how do you determine how to request it? What is the identity of the service provider? Where and when is the service available? By what means do you access the service? What quality of service can you be guaranteed? What payment and settlement models are available? What rights as a service requestor do you have over the service? Where is the manifest that describes how the service is composed? Once requested, what are the models of interaction that might occur during its delivery? Current initiatives such as Universal Description, Discovery and Integration (UDDI), the Web Services Description Language (WSDL) and the Web Services Flow Language (WSFL) are attempting to provide a basis for business integration [66, 13, 39]. We argue that these initiatives lack the accuracy required to compose services dynamically.

Accurate service description offers the promise of reducing the gap between manual and electronic services. This lack of descriptive service information is a result of:

- The heterogeneous nature of services.
- The inherent complexity of services.
- The lack of generic domain independent concepts for describing services.
- Intentional behaviour on behalf of some service providers to limit a service requestor's ability to compare services based on lower-order properties (e.g. price).

Accurate service description will benefit the following activities:

- Discovery: more rapid and accurate forms of service discovery will be possible than is permitted with existing registries or catalogues.
- Substitution: accurate service descriptions form a basis for comparing services, enabling rational optimisation and negotiation, for example.

- Composition: service descriptions may be used to build new services, either statically or dynamically. Composing services based on electronic descriptions could be seen as the web's version of mergers and acquisitions.
- Evolution: services may dynamically update their service descriptions as a result of interactions with service requestors, service providers or their surrounding environment.
- Management: based upon the rich service description languages and operations, architectures may be developed for managing repositories of service metadata. An example of an existing service management architecture is Aurora [44]. This metadata could be used for many purposes including controlling and monitoring the discovery, substitution and composition.

Whilst we acknowledge the importance of the functional properties of services, this paper is primarily focused on non-functional properties. A service is *not* a function. It is a function performed on your behalf at a cost. And the cost is not just some monetary price; it is a whole collection of limitations. This paper is all about these. We consider the non-functional properties to be constraints over the functionality of the service [14]. We believe that a service description is only complete once the non-functional aspects are also expressed. Service description initiatives now need to be focused on determining the properties of services that should be represented and the degree of information that is required. This paper primarily focuses on the former of these issues. The sections that follow attempt to define services, present their lifecycle, outline the entities involved in service provision and consumption, and more importantly detail the properties that comprise services. Finally we present some important uses, related work and our conclusions.

2 What is a service?

In its simplest form we describe a service as an action performed by one entity on behalf of another. This action involves the transfer of value. There are however numerous facets to services, some of which include the nature of the act, the number of parties involved, the manner in which the service is requested and delivered, and the type of value that is transferred. Our definition is intentionally abstract and technology agnostic. This is due to the hetergeneous, and in some domains, rapidly evolving nature of services.

It is possible to categorise some definitions for services based on their focus on technology. The majority of definitions for electronic services (or e-services) use the Internet and/or workflow as a conduit to new revenue or task completion [54, 58, 63]. The latter has led to a new term called "e-process", a business process that composes e-services. Web services have also been described as an aggregation of functionality with a single facade and published for the purpose of use [34]. This is similar to the virtual business processes that define company-level interactions [36]. Other definitions offer a view of services as an abstraction

of a business process [10, 61, 29, 30]. We assert that e-services exhibit minimal constraints on the time and location of *request*. There may, however, be a delay between the request and the *execution*. Such a delay may arise because of resource constraints or because of human intervention required in the performance of the service. We believe that an e-service is characterised by its ability to be automatically *summoned* anywhere, anytime.

Others take a broader view of services. Services are "deeds, processes and performances", the characteristics of which are outlined as intangibility, heterogeneity, simultaneous production and consumption, and perishability [69]. Alternatively services are an "activity whose output is not a physical product", where the performance is for the purpose of adding higher-order (i.e. intangible) value such as convenience [55].

Surrounding these definitions are three immutable features of services:

- Services are actions performed by an entity on behalf of another.
- Services can be contained within other services (e.g. a warranty) [69]. We refer to this relationship by describing some services as *sub-services*.
- Services are an asset [54]. They have an inherent value that is transferred from the provider to the recipient.

We consider services that contain other services (or sub-services) to be either an aggregation or a composition. Aggregations combine multiple services in a manner similar to an Internet portal. Aggregations can be considered a service as they provide a single point for access to multiple services. We refer to a composition as a tightly-coupled integration between sub-services such that the resulting service adds value not previously present within the individual services. This added value may be represented in terms of another service property (e.g. reduced price, increased trust). Within a composition each sub-service is a service in its own right and complex inter-relationships may exist between the sub-services. We prefer to think of these sub-services in a manner similar to inheritance. Service composition should not be confused with functional composition. It has a broader goal that needs to take into account both functional *and* non-functional issues. It may be that we can (functionally) compose a transportation service by articulating land and air transport services. We may equally (non-functionally) compose some hitherto free service with a payment mechanism to form a commercial version of the original service.

Let's consider a concrete example. Builders are a service provider that commonly undertake service composition. The typical builder will not perform every task required to complete a home. Individual services will be required from service providers such as plumbers, electricians, tilers and plasterers. The service being provided by the builder results in a home that meets the plans provided by the service requestor (i.e. the future home owner). In this example we consider services such as plumbers and electricians to be sub-services. We consider all services and sub-services to have an internal plan. That plan describes the flow of operation, pre-conditions, post-conditions and interactions

with the associated sub-services. Building a home requires accurate planning on behalf of the builder (e.g. the plasterer cannot perform their service until the walls have been erected by the builder and any electrical wiring or plumbing has been completed). This internal plan is at the discretion of the service provider.

We assert that each service and its constituent sub-services may maintain a lifecycle as presented in section 3 and non-functional properties (e.g. pricing, payment, security, quality of service) as outlined in section 4.

3 Service lifecycle

The lifecycle of a service can be viewed from three perspectives, that of the service provider, the service requestor and the service broker [10, 12, 18, 34]. A more detailed view has been offered in [21]. In some cases the service broker acts as a "middleman" concealing the true service provider from the service requestor. Under these circumstances we consider the service provider and the service broker to be the same entity from the service requestor's perspective. Understanding that services are complex and heterogeneous we do not wish to trivialise their lifecycle with simple diagrams. We prefer to discuss the perspectives of the service requestor, provider and broker in the sections that follow.

3.1 Service request perspective

The service lifecycle from a service requestor's perspective can be divided into three phases - provider discovery, property discovery and the service request. It is not necessary to perform all three phases when using some services (e.g. well-known services, where the provider and the properties are already known to the requestor, will only require the request phase). All three phases begin with the requestor's recognition that a service is required.

Provider discovery is conducted when the service requestor is unaware of the possible service providers. It begins with the service requestor undertaking a search for available providers. The search is normally conducted via a service broker. The search may result in no providers being found (therefore aborting the provider discovery process) or it may result in one or more possible providers. This completes the provider discovery phase and leads to contact with the individual providers to determine the properties of the service (i.e. property discovery). The property discovery phase may consist of multiple requests for information relating to the service (e.g. availability, quality of service). This phase can be considered a negotiation between the service provider and the service requestor, and generally refines the service information sufficiently for the requestor to formulate a "configuring request". Optionally, this phase may include the fulfillment of a precondition to requesting the service (e.g. registration or membership). We consider this to be an "enabling condition". Should sufficient information about the service not be available, or the service is deemed by the service requestor to be inadequate, then the property discovery phase

is aborted and it may begin with the next service provider. The configuring request is used to activate the service in the next phase.

Finally, the service request phase sees the provision and the consumption of the service. During this phase it may be possible for the service requestor to suspend and then resume the service. The simultaneous production and consumption of services has previously been termed *servuction* [32]. It should be noted that there may be a delay between the request and the consumption phases (e.g. in November you order a ham for Christmas lunch, delivery is only available in late December). Consumption is an optional phase of a service (e.g. you receive a monthly newsletter from a community-related organisation. By throwing it directly in the bin you are not consuming it.) Conversely, a "disabling condition" may be performed prior to termination of the service (e.g. closing a banking service requires removal of all funds from the associated bank account).

3.2 Service provision perspective

The service provision prospective can also be categorised into three phases - service definition, property provision and service delivery. Service definition is the formation of a service offering, resulting in one or more service descriptions. These descriptions are normally exposed externally to an organisation via advertisement with a service broker. Service brokers include the description(s) in a service catalogue that is searched in the provider discovery phase of the service request perspective. The resulting advertised service description can be considered a "service offer".

Subsequently, service requestors may discover the service within their provider discovery phase. After requestor's have initiated contact, property provision occurs. This is the corresponding phase to the property discovery in the service request perspective. Information about the service is provided to the service requestor. This may involve multiple requests for the service information, allowing a requestor to refine the information relating to a service. Service requestor's may initiate this phase directly (e.g. a person with a need for some nails knows that the local hardware sells them but may not know if a certain type is available. In this case the provider is known but property discovery will occur to determine if the specific nails are available.)

Finally, service delivery is performed when a configuring request is received. The service is usually available and awaiting requests. This phase is normally preceded by property provision but in the case of well-known services it may be activated directly. The provisioning of services is regularly performed at the time of request. Some services may have been requested and are awaiting execution based on some trigger (e.g. a magazine subscription). The service provider will usually conduct the property provision and service delivery phases with each new service requestor.

Decommissioning of a service by the service provider is performed when a service has reached the end of its useful lifetime. This is common when a new service takes the place of an existing service. Service providers also undertake

maintenance on deployed services. These changes are considered enhancements or repairs. Each constituting an improvement from either the service requestor's or the service provider's point of view. This may occur after advertising and prior to the disposal of the service.

3.3 Service broker perspective

Service brokers provide a vital aspect of the service provision process (i.e. matchmaking). Service brokers receive descriptions from service providers that act as advertisements for service requestors. These descriptions may be for a new service or an update to an existing service. Once advertised, requests for services can be matched to the service descriptions. Service requestors use the list of possible service providers to begin the property discovery phase. The request and consumption of services will be discussed in the sections that follow.

3.4 Request

Request refers to the solicitation of a service provider for execution of a service contract by a service requestor. In its simplest form it is asking for the service. To clarify, we consider the purchase of one or more items (of any quantity) from the same service provider to be a single request for the same service. The items being purchased are not the service, the process of purchasing is the service.

Regularly there are multiple request methods or mechanisms that can be utilised by a service requestor. The use of these mechanisms may overlap or be distinct. Let's take the example of a bank account statement. The access mechanisms are the regular statement delivered via post, summary statements from automated teller machines, Internet access and via a telephone service. Another example is that of a set of automatic doors. Two mechanisms are available for request. Firstly, the triggering of the door by passing in front of the sensor and secondly, the insertion of a key for after-hours access.

The following is a categorisation of methods used to request a service. The types of request methods include:

- Electronic requests (e.g. URI or web page, email, phone, pager).
- Verbal requests (e.g. face-to-face : buying from a shop).
- Written requests (e.g. invoice or letter).
- Manual action (e.g. turn on TV or radio, raise hand to hail a bus).
- Sensor-based requests (e.g. automated door, barcode scanner).

The purchase of a ticket is an interesting request example. Lets look at it in the context of train travel. When you buy a train ticket you aren't requesting the service. The ticket purchase effectively signifies an "intention" to use the service. The request is only achieved by opening the door and entering the train. This example is made more complex by the fact that the service can be

used without a ticket and that the user can alter the service provision during the consumption process (e.g. the person might get off one stop earlier than planned). The consumption process is outlined in more detail in the following section.

3.5 Consumption

Provisioning (or *delivery*) and consumption represent the next phase after the request for a service. Some services are delivered at a location and time distinct from the request. For example, when booking a trip you might walk to or phone your travel agent. The trip is booked and the service will be rendered at the airport, at the nominated date and time. A specific instance of service delivery can occur within the context of an existing service. This is evident when you catch a bus that is moving between points A and Z. You request the service (i.e. hail and get on the bus) at point D and your consumption of the service ends at point G (i.e. you get off). In the example provided it is interesting to note that:

- The service provider (i.e. the bus company) may deliver the service and it is never consumed (i.e. the bus is driven from A to Z and nobody gets on). This is the characteristic of perishability described in [69].
- Multiple service requestors may consume the same delivery of a service by the provider (i.e. you are on the bus at the same time as another person). Each service requestor's delivery may be different (i.e. you get off at a different place to another person).

Consumption and delivery of a service can be categorised into one-off (e.g. eating a meal in a restaurant) and continuing (e.g. having the newspaper delivered to your house). Delivery also has a number of interesting features that include suspension and load-balancing. Some services offer the ability to suspend and resume the delivery of the service (e.g. halting delivery of milk and papers while on holidays). In some cases this has the effect of extending the life of a service and altering the obligations associated with the service (e.g. payment).

Some services require a form of "load-balancing" during or prior to the consumption. This is common in the development of large-scale information systems. However, load-balancing occurs more regularly in everyday life. An example is found when attending the theatre, there is an implicit understanding that people arrive before the scheduled start time so that seating can be conducted in an orderly manner. Alternatively, franchises are a form of balancing the requests across suburbs or areas for a particular service.

Service requestors are considered to have *contact time* with respect to a service. Contact time can be regarded as an aggregation of the time spent negotiating with the service provider, requesting the service and consuming the service. Consumption of the service may be a non-contiguous period of time (e.g.

the service offered by a university is the education of a student in a particular domain. This however only requires attendance at specific times).

To summarise, we consider the interaction that occurs between service providers, service requestors and service brokers to be a spectrum of possible provision. There are three distinct stages. Service definition is the refinement of an existing service or definition of a new service by a service provider. This results in one or more service descriptions that can be advertised and subsequently discovered. We term services that have been advertised with service brokers, "service offers". Service offers are utilised by the service broker to match service providers with service requestors. Service requestors and providers may then enter a multi-stage negotiation. The result of the negotiation is a service contract. It defines the obligations of each party and any surrounding terms and conditions. A service requestor may then enact the service contract.

4 Non-functional properties

We now present a discussion of the *non-functional* properties associated with services. As previously mentioned we consider these non-functional properties to be constraints exhibited over the functionality of the service. The non-functional properties of services include temporal and spatial availability, channels, charging styles, settlement models, settlement contracts, payment, service quality, security, trust and ownership. Each of the properties presented in this section is deserving of a separate paper. Instead, we try to reveal sufficient detail with respect to each non-functional property as to outline the complexity involved with accurately describing them. The non-functional properties outlined in this paper have been based on a review of existing commercial services. Other properties may be discovered during the course of our research.

4.1 Availability

This section provides a discussion of the general challenges associated with representing the temporal and spatial availability of services. Subsequently we offer some candidate representations for these concepts. We consider availability to be the temporal (i.e. when) and spatial (i.e. where) constraints applied to a service. We recognise that different channels (request or delivery) may have different spatio-temporal constraints applied to their availability. Availability in this context is not intended to refer to concepts such as high availability that are common in a business continuity scenario. We realise the need to represent the spatio-temporal characteristics of services together when we refer to availability. Spatio-temporal approaches that can be used for applications such as fire, weather, ship and plane monitoring are offered in [48].

Availability is a complex property of services. This complexity is evident in the context of the following services:

- Services that are regularly on the move (e.g. taxis, trains, ice-cream vans).

- Services where an implicit understanding effects the advertised availability. (e.g. you attend the theatre, it starts at 7:30pm. There is an implicit understanding that you need to be in the lobby prior to that time so that seating can take place.)

- Services like the theatre where there is a suspension and resumption (e.g. an intermission).

Additionally, when you attempt to represent this complex spatio-temporal information other issues need to be addressed:

- Dynamic and retrospective refinement: Numerous services intentionally provide incomplete spatio-temporal information (e.g. when you buy an airline ticket you know the airport where the plane departs from. The spatio-temporal representation is further refined at check-in to include a departure gate lounge/number, boarding time and a seat number.) The same type of refinement occurs when you utilise a hotel room (i.e. room number, check out time). Retrospective refinement is common for moving services. A taxi driver is supplied with a destination when someone uses a cab. This service can be refined from a general path to a particular route once the service has been provisioned.

- Absolute versus relative descriptions: Availability of a service may be specified with respect to another object (e.g. an emergency phone is available 3 km south of a particular overpass the freeway. This is also referred to as orientation and is defined using the primary object, a reference object and a frame of reference [16]. Whilst spatial in nature, the same issue arises in a temporal context. (e.g. another train to Golders Green will arrive 8 minutes after the next train that passes by). These relative descriptions could also be used in reference to a sub-service.

- Uncertainty: Different temporal representations can be used but they assume a "degree of certainty" about the information being represented [4]. Uncertainty increases with a reduced frequency of sampling [53, 59]. How do we know that a bus will arrive according to its timetable? We can assume that it will arrive on time or we can stand at the bus stop and continually check. It is important that uncertainty is communicated to the service requestor.

- Multiple representations: The ability to support multiple representations within a single spatial availability description (e.g. when you buy a ticket to the basketball, the ticket nominates the stadium door number, the row and seat number, and the game start time).

- Granularities: The granularity used to represent availability will need to be different depending on the service and possibly the domain (e.g. a petrol station might have a more course-grained availability than a plane).

- Exclusivity: Some services have exclusivity arrangements relating to their availability (e.g. an appointment for the doctor or hire of a tennis court). This restriction is also visible when television networks purchase the rights to sporting events. Accordingly, this property of service provision may have an impact on the price of the service.

For decision-making reasons, service requestors may need to be aware of more than the availability of service request and delivery times. To enable accurate scheduling of multiple services, the service requestor may be specifically interested in the duration of the service or the approximate service completion time. These differing representations may be required when performing service discovery, service advertising, service composition, and when referring to service quality. We consider cases where there is a distinction between the targeted versus the achieved availability a property of service quality. This is discussed in more detail in section 4.8.

Increasingly, services are being offered using a location-based approach (e.g. where is the nearest convenience store to where I am now?). Multiple services are referenced in this context, the discovery service (used to find another service) and the service(s) being searched for. The representational challenges outlined above apply to these mobile services.

4.1.1 Temporal and spatial representation

We recognise the need to represent temporal periodicity using different techniques. Within a technique there is need to support various granularities or alternatively represent time as a relationship (e.g. service "X" begins after service "Y"). Common temporal granularities include seconds, minutes, hours, days, weeks, months and years. Approaches for capturing these granularities and their relationships (e.g. finer-than, groups-into) have previously been offered [7, 2]. Temporal database literature has well-defined terms such as chronon (non-decomposed unit of time), timestamp, lifespan, event and interval [31]. Analogous to chronons is the concept of a moment [3]. Each of these concepts offers insight into the expression of granularities for temporal availability. A useful summary of the problems associated with using temporal timestamps such as now are outlined in [15].

Calendars and timetables are possibly the most common and easily understood method of representing current, future and past time. The granularity of these representations may differ (e.g. calendars use days, months or years whilst timetables use hours, minutes or days). The importance of not using a single uniform calendar (e.g. the gregorian calendar) is outlined in [11, 40]. This first paper also offers a useful discussion of calendar algebra, implementation and expression. Different calendric systems (i.e. Geologic, carbon-14, tree-ring, julian and gregorian) are mentioned in [33]. It should be noted that additional semantic meaning (e.g. public holidays) can be inferred from some representations such as calendars [11]. Another method for representing date and time is the ISO standard 8601:2000 [22]. This standard has been defined primarily for information interchange, primarily for software to software exchanges.

The artificial intelligence community utilises dating schemes, constraint propagation and duration-based representation (e.g. PERT networks) for temporal representation [4]. Within the spatio-temporal database community sets of object, location, and timestamp triplets have been used to represent time evolving spatial objects [64]. Three temporal specification issues are outlined - data type support, index construction and query processing. Each of these issues is applicable to services (e.g. data type support - service definition languages, index construction - service catalogs, and query processing - service discovery).

Spatial representations are often required to describe topologies, orientation, shape, size and distance [16]. Spatial modelling is common in geographical information systems. The primary standards bodies with respect to geographic information are the International Organization for Standardisation and the Comité Europeo de Normalización. Their respective technical committees have defined multipart standards to represent geographic information. A discussion of spatial models and their classifications (comprehensiveness, structure, theoretical foundation, modelling technique) are found in [24].

Within the context of services, we are attempting to describe the location of the service request, the service provision and the service delivery. Spatial representations are generally an abstraction of another object. Examples include:

- Labelling schemes: Generally accepted naming conventions that are applied to objects. These include and are not limited to:
  - Postal addresses for building, houses, apartments and post office boxes (e.g. The White House, 1600 Pennsylvania Avenue, Washington, D.C. 20500).
  - Spectra: For example TV and Radio (UHF, VHF, HF, AM, FM) services. This primarily refers to broadcast mechanisms.
  - Uniform Resource Identifiers: Includes representations for items such as web, ftp, telnet, email, and news resources [6].
  - Mobile and standard telephone numbers.
  - Names for train stations or bus stops.
  - Internal room numbers (e.g. hotels, motels).
  - Ethernet addresses/IP addresses.
- Routes: The path from X to Y including any intermediate points. (e.g. a freeway or a bus route). This is sometimes referred to as a polyline in the spatial literature.
- Regions: A representation for an area (e.g. airports, franchise area, amusement parks). Within a region, a specific sub-region may be of particular interest (e.g. within the amusement park region, the car park region is of initial interest).

Additionally, spatial representation can be undertaken using latitude and longitude. Latitude representing the distance on the meridian north or south of

the equator. Longitude representing the distance on a meridian east or west of the prime meridian (e.g. moving services can include boats or taxis). It should be noted that the additional dimension of altitude is useful for services such as planes (in transit). Representation and indexing of moving-point objects is discussed in detail in [53, 59].

Filtering is sometimes applied to the request channel by the service provider. This mechanism limits the spatial availability of services to some requestors. Some examples of filtering include calling a well-known phone number that redirects the requestor to the appropriate service provider in your region, or franchises that operate only within a specific suburb(s).

4.2 Channels

The term *channel* has different meanings in numerous domains. In telecommunications it can be considered as the path via which a signal travels. In radio television it is a frequency, in computer hardware it is a connection between devices and in a general sales marketing it is the path from vendor to consumer, possibly via intermediaries [28]. A channel has also been defined as the means by which a user requests a service and receives the resultant output from a service [20]. This distinction is useful when considering services that are delivered at a scheduled time or interval after the request, and services with multiple, selectable delivery channels.

With the introduction of distinct request and delivery channels the following implications are visible:

- Two different channels may offer overlapping or distinct operations. (e.g. a bank balance can be requested over the counter or via the Internet, however a bank cheque can only be drawn over the counter.)
- Channels may support varying properties or characteristics. Temporal availability is probably the most common. Internet-based services operate in a 24x7 mode, whilst branch offices may be open Monday through Friday from 9am - 5pm. Other properties that vary may include price, quality of service and security.
- Some channels offer an operation that allows redirection to another channel. (e.g. call forwarding from a home or work phone to a mobile phone.)
- Service providers may have preferred request or delivery channels. These channels may be offered for cost-effectiveness reasons.
- Separation of the request and delivery channels may introduce the need to acknowledgement a request. In some cases this is provided in the form of a receipt.

Channels based on Internet technologies may increase the exposure of an organisation's services. This may subject the services of a provider to increased scrutiny. Some channels utilise broadcast techniques as a means of addressing

an unknown number of providers (e.g. placing a wanted advertisement in the classifieds section of a newspaper) or requestors (e.g. receiving news updates from a web site). This technique is more common with delivery channels and is commonly referred to as "pushing". Broadcast channels have the unique property that they may not have been explicitly requested (e.g. a television or radio station). This example is additionally unusual as there is no associated request channel.

Channel length is determined by the number of intermediaries between a service requestor and a service provider. The length of the channel has been noted as shortened for services [56]. Channel length increases for services that are discovered and requested utilising a service broker. Some well-known channel paths from provider to requestor include wholesaler, retailer, value-added reseller, reseller, dealer and distributor. Franchising also increases the channel length for some services (e.g. some franchised services are performed by subcontractors not the franchisee). Interestingly, depot theory defines goods as "moving towards the point of final consumption at a rate established by the ultimate consumer" [43]. It is possible that this *channel speed* might hold for services. Additionally, it might be possible to show that consumers also drive the rate of evolution of a service.

Whilst channels facilitate the request and delivery of services, the endpoint and the message being transmitted is of more interest. WSDL is a recent initiative aimed at describing such endpoints and the means by which they are accessed. Better termed an interface definition language, it is not the role of WSDL to define the non-functional aspects of services (e.g. quality of service, payment obligations). Channels normally require a pattern of interaction or dialogue that outlines the expected requirements of all parties. Numerous initiatives exist within this area (e.g. RosettaNet Partner Interface Processes [19], Conversation Definition Language [35], ebXML and BizTalk [52]) and we consider a comprehensive survey of these frameworks outside the scope of this paper.

At this stage it is important to identify the distinction between the terms mobile and moving. We consider a service to be moving when the service provider has a spatial availability that regularly alters. We consider service requestors to be accessing moving services when they themselves have a regularly altering spatial context (i.e. they are mobile).

We acknowledge that some of the properties presented in this paper have a direct implication on channels (e.g. security and quality of service) but these will be addressed in their respective sections.

4.3 Charging styles

The styles presented here reflect the charging technique applied by a service provider for the use of its service. We consider these charging styles to be orthogonal to the price. It is our assertion that the charging style is selected (possibly by default) before a charge is applied to the service. The selection of a charging style is currently conducted statically prior to service advertisement. It

should be noted that the charging style may impact the decision making process of the service requestor.

The following charging styles have been identified:

- Per service request or delivery: Represents the style based on the service being requested or delivered rather than a property of the service being provided. Examples might include a carpet cleaner, physiotherapist, fixed price local telephone call, and home loan application.

- By unit of measure and granularity basis: Represents the style based on an aspect of the value being transferred during the service provision. This granularity can be quantified using categories such as length (e.g. mm, cm, m, km, mile), volume (e.g. m^3, litre), weight (e.g. gram, kilogram), area (e.g. m^2) and temporal aspect (e.g. sec, min, hr, day, month, year). Examples include *volume* - soil or fuel, *length* - wood or curtains, *area* - block of land, *weight* - meat, *kilowatt* - electricity, *kilobyte* - T1 connection, and *temporal* - per night for a hotel room or per month for a mobile phone plan.

- Percentage or ratio basis: charging represented as a percentage or ratio of some aspect of the service. (e.g. % of revenue, % trailing commission, % basis points on a loan).

Service providers may utilise an aggregation of charging styles. An example of this is a telecommunications provider (e.g. AT&T, Deutsche Telecom). The services of a telco are charged using multiple styles. This includes granular services such as per minute or second phone calls (either interstate, international or mobile phone) and per month line rental. Charges such as the initial connection fee and fixed cost local phone calls are charged on a per service request basis.

Sometimes the charge for a service is redirected to another entity. An example of this is a free web-based email service. No cost is applied to the service requestor but advertising is used to pay for the service. The associated entity may be charged using one the styles outlined above.

4.4 Pricing strategies

Pricing strategies differ between goods and services. This is due to the intangible nature of services [69]. Pricing strategies reflect the technique used by a service provider as the basis for determining the price associated with a service. The following strategies are offered by [27]:

- Cost-based pricing: simplistic form based on determining the costs incurred in providing the service. Service providers normally add a margin to allow for price negotiation and profits.

- Demand-fluctuation pricing: used when demand for a service varies widely. May involve the development of a differential pricing scheme for peak and non-peak periods, in an attempt to increase demand in non-peak periods.

- Capacity pricing: this method attempts to find a balance between the demand for the service and a competitive price. The intensity of demand will effect the service price. It is common in equipment based services.
- Benefit pricing: this method is used when the cost of providing the service is totally unrelated to the benefit perceived by the service requestor. It applies to services such as restaurants.
- Price bundling: used when services are bundled together and the price of the service is less than the sum of the constituent services. Common in banking, travel and software industries.

Services offer an opportunity for flexibility of pricing. This is due to the level of configuration that can be applied to the service characteristics [41]. Evaluating the perceived cost is simpler with goods than with services. With a good or commodity you can evaluate the physical features, deduct the perceived cost and determine if there is a value [27]. The perceived value is integral to the decision making process of the service requestor.

4.5 Pricing factors

We use the term pricing factors to refer to those aspects surrounding a service that have an effect on the resulting price. We group these according to the level of visibility to the service requestor. Outlined below are some examples of pricing factors. It should be noted that some factors are arguably applicable to either category. An example of this is wholesale cost. Not normally known to most customers, the wholesale cost would be visible to a person who previously worked for the service provider.

- Visible: Regulatory charges/changes (e.g. state, federal or value-add tax), quantity involved, currency exchange, payment methods (e.g. cash or credit card), loyalty or member ship programs, shareholder or trade discounts, perception of value, and cooperatives (consumer groups achieving economies of scale). Some of these factors can be considered incentives for price reduction.
- Hidden: Wholesale cost, production cost, profit margin, future revenue or profit potential, currency hedging (i.e. normally in import or export scenarios), inventory costs (i.e. length of time on shelf), quantity produced, competitor actions, exclusivity of the service, cartels (organised bodies used to define the price of a service) and the level of service. The majority of these factors are relate to cost recovery by a service provider.

Depending on the level of domain-specific knowledge, a service requestor may or may not be aware of some of the normal market characteristics that also effect pricing (e.g. number of competitors, market size, demand vs supply).

4.6 Settlement

Settlement is a process that reflects the mutual obligations of the service provider and the service requestor. A common obligation of the service requestor is payment. A service provider's obligations usually involve delivery of the service. The settlement process is normally defined by the service provider and is included as part of their business model. The settlement process (and its ordering) is sometimes defined by the service environment (e.g. stockmarket). In the financial domain the term settlement is more narrowly defined with respect to monetary exchange [49].

4.6.1 Settlement models

Packaging of service requestor and service provider obligations into a defined process results in a settlement model. The settlement model reflects the ordering and relationship between each parties obligations. None of the settlement models presented in this section result in a transfer of ownership (see section 4.10). The service requestor does however consider some form of value to be transferred during the provision process.

Some well-known models are the *transactional* and the *rental* models. The transactional model can be described simply as delivery for payment. It can be a one-off delivery or include multiple deliveries of the same service. The later implies a longer term relationship. The rental model is the familiar concept of being "on loan" (e.g. a video). Within the rental model, explicit temporal or spatial constraints may be imposed by the service provider (e.g. (a) the video is to be returned by 6pm tomorrow, or (b) when hiring a conference centre the service is found at a physical address). Depending on the service, rental may involve a short-term relationship (e.g. holiday unit) or long-term relationship (e.g. local video store membership).

Specialised forms of the transactional model are:

- Subscription: Normally implies a long-term relationship between the service provider and the service requestor (e.g. magazine subscription, mobile phone plan). It can be regarded as multiple deliveries and consumptions of the same service.

- Metered: Almost identical to the basic transactional model however the relationship may impose restrictions that make it difficult to alter the service provider (e.g. water, electricity). The service provider may supply equipment (e.g. water metre) as a means of measuring the service provided. Payment obligations may be settled less frequently (e.g. quarterly) than the standard transactional model.

- Facilitated: This model involves the service provider acting as a conduit or facilitator to another service provider (e.g. broker or financial planner). A long-term relationship could be involved. The facilitator may be involved in during the service discovery, service request, service delivery and settlement functions.

- Escrow: Used when there is an identified trust issue with either party. This model is better suited to "tangibles" rather than "intangibles". The parties lodge either payment or the commodity. Once complete, the escrow organisation facilitates delivery of the payment or the commodity to the respective parties.

- Swap: Agreement between the parties that the services being traded are of equal value. There is no payment involved.

A specialised form of the rental model is a "lease". Features of the service may vary depending on the type of lease. A service lease incorporates the cost of maintenance, insurance and taxes in lease payments. An operating lease assigns responsibility for maintenance on the lessee. This model may include the option to purchase upon completion of the lease (e.g. leasing of a car). Each lease is normally for a one-off instantiation of the service.

Some examples of the settlement models listed above include:

- Transactional: Purchase of a meal at a sit-down restaurant. The service involves the provision of the items listed on the menu. Service requestor nominates the menu item(s), the service provider (i.e. restaurant) prepares and provides the item. Subsequent to consumption, the settlement is finalised by the service requestor furnishing payment.

- Rental: Children playing at the local video game arcade insert coins into the machines in exchange for games credits. Upon expiry of the credits additional coins are required for the device to function. Partial settlement (i.e. payment obligation) is conducted prior to the service delivery. The obligations of the service provider occur subsequently.

- Facilitated: Organisations can use high-profile or high-traffic web sites for advertising purposes (e.g. web-based email). Settlement occurs between the advertiser and the web site rather than with the service requestor. Settlement involves the provision of advertising in the web site in return for payment.

Settlement doesn't preclude parties other than the service requestor and service provider. An example of a *multi-party* settlement might involve the transfer of ownership of a vehicle. The two parties involved exchange the car and the payment. Notification is required to be sent to the relevant motor vehicle department. With multi-party settlements there may be varying degrees of binding between the parties involved. An example of a tightly bound third-party might include a credit card provider (e.g. a bank) and an example of a loosely bound third-party might include a company that provides software used during service provision (e.g. a word processor).

Service providers sometimes trigger the obligations of the service requestor by using a request for payment or an invoice. This indicates the the service provider has completed their obligations.

4.6.2 Settlement contracts

Attached to the service may be a list of terms and conditions. These conditions are formalised in a contract and govern the responsibilities of all parties involved in the service request and provision. Contracts are considered binding agreements between parties [9]. Examples of settlement contracts in an offline environment include:

- Bill of Lading: Used normally in a moving or import/export context. Defines details of transportation (e.g. who, what, where) and what happens should something go wrong.
- Promissory Note: Outlines the terms and conditions of a loan (e.g. required repayments, interest rate and policies surrounding the loan.

More familiar examples include the terms and conditions associated or expressed with items such as credit card applications, tickets for transportation or entertainment, and policies (e.g. insurance). We assert that these contracts are representations of the promises of each party. Both parties must be agreeable with respect to the contract before it is instantiated. An implementation of the infrastructure required for electronic contracts is outlined in [26]. In the case of a warranty, contracts may prove to extend the life of a service beyond the initial transfer of value.

Recourse is available in some cases to either the service provider or the service requestor. In cases where obligations of either party are not realised there may be some level of re-negotiation performed. A contracting protocol that includes the ability to decommit is outlined in [60].

4.7 Payment obligations

Payment obligations may be required at any stage (e.g. upfront, in arrears, staged installments) in the service provision process. These obligations are normally outlined to the service requestor as part of the negotiation process and are included in any attached settlement contracts (see section 4.6.2). Service providers or their surrounding environment determine a valid set of payment instruments that are used to fulfill this important obligation of the service requestor.

Payment instruments are used within the context of a payment model. The entities and information flows associated with payment models have previously been outlined in [51]. Additionally we recognize that payment protocols are sometimes utilised as a mechanism for controlling the flows within these models. These are also referred to as settlement schemes (see financial domain definition of settlement in section 4.6). Some common payment protocols include: Society for Worldwide Interbank Financial Telecommunications [23] and Health Level 7 [1].

We consider the term payment instruments to be relatively self-explanatory. We consider payment instruments to include items such as cash, cheques, direct funds transfers, credit or charge cards, travellers' cheques, wire transfers,

postal or money orders, securities (i.e. stocks, options, warrants), bank bills, vouchers, stored value cards, digital cash and anonymous cash. These payment instruments are not one-dimensional. A useful summary of payment instrument dimensions is available in [42]. These dimensions have been summarised here to reflect the complex issues associated with representation:

- Offline: Can the payment instrument be used in a non-electronic environment?
- Online: Can the payment instrument be used in an electronic environment?
- Acceptability: The relative acceptance of the payment instrument by the receiving party.
- Traceability: The service requestor, service provider (and any interim parties) and their associated operations/actions can be traced.
- Refutability: Neither party is capable of denying either payment or service receipt.
- Negotiability: Does the payment instrument have the ability to alter the negotiating conditions associated with the commodity or service?
- Liquidity: Is it possible to liquidate a holding in the payment instrument within a short timeframe?
- Expiration: Does the payment instrument have a fixed lifetime?
- Provider Coupling: To utilise the payment instrument are you coupled (e.g. by way of an card, account, password loyalty program or PIN) to the provider?
- Transferability: Refers to the ease with which an instrument can be transfered to another instrument.
- Security: Does the use of the payment instrument occur in a secure environment?
- Immediacy: How quickly is the value of the payment instrument transferred from one party to another?

Table 1 outlines the relationship between payment instruments and payment dimensions. Understandably subjective in nature, it should also be noted that this table will be different depending on the context within which it is viewed (e.g. countries like the United Kingdom have a high acceptance of cheque payments. This may not be the case in non-cash centric economies such as Japan).

4.8 Service quality

Quality is a another multi-dimensional property of services. Service quality is largely a domain-specific characteristic that can be viewed from two distinct perspectives. It represents the view of the requestor that an organisation is sufficiently competent to provide a service [57, 38]. This perspective encapsulates the internal expectations or perceptions regarding the service. These expectations are sometimes based on past consumption of the service or from advertising information. The alternative perspective is that of the service provider having a level of commitment to providing the service. Service quality is regularly viewed from this latter perspective, resulting in the misconception that service quality is only about issues such as performance, reliability and conformance to quality standards.

The most notable work on measuring customer perceptions of service quality is SERVQUAL [50]. This work produced a 22 item scale that measured perceived service quality along five dimensions:

- Reliability: Encompassing the dependability and accuracy of the service.
- Responsiveness: Encompassing promptness and the willingness of staff to assist.
- Assurance: Encompassing attributes of staff that conveyed trust and confidence to the user (e.g. knowledge and courtesy)
- Empathy: Level of caring and personalised attention provided to the requestor.
- Tangibles: Encompassing concrete or physical aspects of the service (e.g. cleanliness, equipment).

It is understandable that electronic services would regard tangibility as of relatively low importance as compared with dimensions such as reliability and responsiveness. The dimensions of assurance and empathy become very difficult to embody in an electronic environment. It has been previously noted that consumers evaluate electronic services based on concrete cues (e.g. one-click ordering), perceived attributes (e.g. speed), other dimensions (e.g. ease of navigation) and higher-order abstractions (eg. convenience) [70]. The same report outlines eleven dimensions consumers evaluate for electronic service quality (e-SQ): access, ease of navigation, efficiency, flexibility, reliability, personalization, security and privacy, responsiveness, assurance and trust, site aesthetics and price knowledge.

Service providers may commit to providing a certain level of quality. This commitment is sometimes formalised using a *Service Level Agreement*. Service level agreements can be considered as binding contracts that are agreed between a service provider and service requestor. Penalties are normally imposed for non-compliance with the agreement. Commitment to a service can be bound into the contracting protocol [60]. This offers a method of backing out (or de-commiting)

from a service, assuming that the agreed penalty is paid. Service providers also utilise guarantees or warranties to express commitment to a service.

To date, service quality literature in an information technology context has largely been focused on the area of networking. However service quality in the context of electronic services provokes interesting questions that are yet to be addressed:

- How do you represent the declarative service quality requirements of a service requestor or the service quality capabilities of a service provider? Should the service quality capabilities of a service provider be included in an advertisement?
- Service quality is regularly referred to in the context of a service provider and a service requestor. What are the needs for service quality between the service requestor and a service broker, or between a service and its constituent sub-services? Is the service quality promises between a service and its sub-services solely a resource management issue?
- Within a service management architecture, should service quality monitoring and auditing be performed? Alternatively, is a separate third-party required to validate the service quality promises of each party? This may be useful for services where a delay exists between the request and the delivery of a service. Service providers could lodge promised service quality levels with the external party and report the achieved level of quality upon delivery of the service.
- How do you offer dynamic service quality configuration and re-configuration? How does service quality re-configuration between a service and its sub-services effect service requestors? How are these changes communicated to the requestor?
- What concepts within service quality apply to services (e.g. commitment categories such as deterministic, statistical and best effort [9])?
- What incentives are there for service providers to achieve the promised levels of service quality? Are de-commitment penalties sufficient?

Service quality should be an attempt to reduce the difference between expected and actual service provision. In [37], service providers are noted as needing to avoid offering a service of poor quality that caters for too small a market segment and offering a high quality service that is too costly to attract enough customers. A useful survey of service quality frameworks is outlined in [5].

4.9 Security and trust

Security and trust are foundational properties for electronic service provision. The issues surrounding their use in services is outlined below. We have not attempted to discuss representational issues for either of these topics.

4.9.1 Security

Security is increasingly being viewed as a mandatory component for facilitating electronic commerce. It alleviates concerns relating to identity, privacy, alteration and repudiation of information transferred between parties [8]. We commonly think about "on-the-wire" security that pertains to the request and delivery channels of a service, especially then the payment obligation of the service requestor is being finalised. Security protocols such as the Secure Sockets Layer and Transport Layer Security are becoming widespread for this role. Common approaches to security within organisations involve the implementation of a Public Key Infrastructure (PKI). The management overhead involved with PKI infrastructures has limited their widespread implementation.

We believe that individual aspects of service descriptions should be secured. Think of a service provider who interacts with retail clients as well as wholesalers. The different views of the service description would require securing. More information, and a different price may be available to the wholesaler. This concept is similar to visibility rules in [65]. Alternatively, multiple advertisements could be generated by a service provider with access controls applied based on the type of requestor accessing the information.

Security becomes a decidely more complex property in the context of sub-services. We propose the following questions:

- When a client interacts with a service and authenticates it - should they also authenticate all the sub-services? Do we require security certificates that validate aggregations or compositions of sub-services?
- How do you secure a service to stop it from being composed within another service? Securing the discovery of the service may be an alternative. A secure service discovery service has previously been offered in [17].
- What are the implications for a service when some sub-services require security and others don't?
- What happens when sub-services have differing policies with respect to client information? How do you express the security surrounding the client information to the service requestor?
- How do you express security for electronic services delivered manually (eg. using a book store's web site to order a book that is to be delivered via a courier or by the postal service)?
- What consitutes an infringement to a security promise? How are infringements by any party to a service managed (e.g. penalty payment, removal from a composition)?

4.9.2 Trust

It is easy to become very philospohical when discussing trust. As humans we utilise trust in a subjective manner for almost everything we do. A useful

discussion of trust is offered in [45]. Marshs' thesis highlights that trust is a reinforcing attribute that balances perceived risk, cost and benefit. These same concerns are present in the service provision process. Trust will be integral to ensuring the dynamism of service provision.

Reputation mechanisms are an attempt to embody trust. Two such mechanisms have been offered to address the issues of misrepresentation and alteration in electronic marketplaces [68]. The implementation of reputation mechanisms may be useful but concepts from non-electronic service provision may prove useful. People tend to be satisfed that when acting within a group they will be able to increasingly trust a service provider. An example can be found in the financial domain with managed funds. People perceive more trust in a managed fund that has significant funds under management. This grouping of service requestors acts to abstract the relative importance of an individual requestor over another, and to provide incentive to a service provider by reducing the overhead of dealing with all the requestors individually. The same concepts are visible in groups such as a cooperative.

The following issues arise with respect to trust in service provision:

- Service requestors largely view trust from two perspectives: whether they trusting the intentions of a service provider and whether they trust the competence of a service provider.
- How do you represent the trust of service providers or service requestors within a particular context? This question arises from a definition of reputation - "the amount of trust inspired by a particular person in a specific setting or domain of interest" [68].
- In a decentralised system how is knowledge relating to trust distributed, particularly changes to the perception of trust for a party?
- How do you trust a composition (e.g. service A is composed from subservices X, Y and Z)? Can an external party validate a service and provide a level of reputation based on previous interactions?
- What are the implications or penalties for parties that are distrustful?
- Similar to a managed fund, is past performance of a service provider visible to the service requestor thereby reducing the perceived risk?

Trust can be both mutual (service provider doesn't trust the service requestor and vice-versa) and exclusive (the service provider trusts the service requestor but the service requestor doesn't trust the provider). A model for information flow within systems where mutual distrust is present has been offered in [46].

We believe that access to a rich and accurate service description will increase the level of trust present between service providers and service requestors. Service requestors are sometimes cautious when dealing with providers where all information has not been disclosed or where it is difficult to retrieve information

about the service. The following section outlines some of the right associated with services from a service provider and a service requestor perspective.

4.10 Ownership

Provision of goods usually results in a change of ownership from the service provider to the service requestor. This is the case for all settlement models except the rental model (see section 4.6). Services don't involve a transfer of ownership. Service providers own the intellectual property associated with the provision process. Service requestors do however have a limited set of rights that are associated with a service. These rights provide a degree of control over the request and consumption of the service.

The rights available to service requestors with most services include:

- Right of comprehension: Service requestors have the ability to question with the intention of understanding the service to be requested.
- Right of request: Once an advertised service offer has been refined into a service contract, via negotiation between the service provider and the service requestor, the service requestor can choose not to request an instance of that service. The service requestor maintains the right to request the service from another service provider.
- Right of premature termination: Service requestors normally have the ability to prematurely terminate a service. The service provider may continue provision of the service (e.g. a movie continues to play if you get up and walk out) and may choose to apply some form of penalty for partial consumption. The latter is common in the mobile phone industry where penalties apply for early termination of mobile phone plans contracts.
- Right of suspension: Suspending the delivery and therefore the consumption of a service can act as a useful method for extending the service provision process. An example of a suspension is asking the milkman to not deliver while you are on holidays. Correspondingly, the right of resumption continues the delivery and consumption of a previously suspended service.

5 The use of non-functional properties

Non-functional properties can be used during the numerous operations of services. The service life cycle is controlled, by the service provider, from conception, to decommissioning where a service is no longer to be offered. It typically involves the definition (or creation), advertisement, invocation, and decommissioning. All these aspects form part of the general evolution of a service.

Once a service has been defined, one or more descriptions can be generated. These descriptions, sometimes referred to as advertisements or offers,

are normally published with a catalogue. Matchmaking is conducted by catalogues using the search criteria provided by a requestor and the descriptions from service providers. Currently service descriptions are primarily static and are insufficient to allow detailed refinement to occur at the service catalogue. Services, and consequently their descriptions, may require modification as a result of interactions with service requestors, other service providers or their surrounding environment.

5.1 Discovery

We consider discovery to be the process of finding candidate service providers. This does not include the refinement of the requestor's understanding of the service. Service catalogues (e.g. YellowPages) currently maintain lists of service providers categorised according to proprietary classification schemes. Non-functional properties are largely restricted to the temporal (e.g. 24x7) and spatial (e.g. address) availability, a request channel (e.g. a telephone number) and possibly a geographic region. Temporal and spatial availability for all request and delivery channels, quality of service, rights of the requestor over the service, settlement models, charging styles, security and trust are not currently provided by catalogues to requestors. Inclusion of these non-functional properties within a published description allows for more detailed refinement to occur through the service catalogue.

For example, a requestor located in Canada, wishes to discover a service that provides stock quotes from the Hong Kong Stock Exchange. The requestor wants to ensure that the following non-functional properties are addressed by the provider: (1) that the software is developed according to the ISO 9001:2000 quality standard, (2) that the request and delivery channel is the web, (3) that the settlement model is subscription-based, (4) that the charging style is by a unit of measure (i.e. time) and granularity based (i.e. monthly), (5) that payment can be made in US dollars, (6) that the information is no more than 20 minutes old, (7) that username and password security is required to access the service, (8) that they trust the service provider based on the fact that greater than 100,000 people currently utilise the service, and (9) that they have the right to terminate the service after six months with only 2 weeks notice. For non-vague service requestors, this type of service discovery is not currently possible. It is hoped that this level of description and matchmaking will reduce the need to contact providers only to discover the requestor's requirements do not match the supplied service. Publishers may wish to target specific catalogues with a more detailed description, whilst providing a high-level overview at other catalogues.

5.2 Substitution

Substitution uses accurate service descriptions to allow rational optimisation of sub-services within a composition. Taking two services A and B and combining them sequentially may be easy to conceptualise. Service A may be an electronic news report and service B an electronic weather report. If we try to outsource

them then difficulties arise. A may only be offered in the USA and B in Chile. Pretty useless if you live in Australia; and pretty useless too if A is available on weekdays and B only on weekends. If, as virtual service builders, we want to configure such a composite service, then the non-functional properties of contributing services must be examined carefully. This discussion raises the notion of *substitutability* in the context of composition. In software engineering, there are established rules about the substitution of one function by another. These rules are captured in the approach known, not coincidentally, as programming by contract. There, we may substitute one function F by another G if G has weaker preconditions and stronger postconditions.

Suppose we have, at some time in the past, composed a configuration that contains A, and we encounter another potential service A'. It seems safe to assume that, if A is only available on weekdays but A' is available seven days a week then, all other things being equal, we can substitute the newer one. Thus we may anticipate a number of substitution guidelines. A' may be substituted for A provided:

A' is cheaper than A
A' is more spatially available than A
A' is more temporally available than A

These rules may be compared with weakening the preconditions; for example, a service that is more geographically available has, essentially, weaker conditions attached to its use. Other properties may be associated with the concept of postcondition. For example, a service with *stronger* consumer rights may always be substituted for one with weaker obligations.

5.3 Composition

Composition is a way of defining a new service. Static or dynamic composition requires an accurate and detailed understanding of the services involved. Composition produces tightly-coupled integration between sub-services to ensure that value is added over the sum of the individual services. As a composer of services, discovery and substitution are integral. Discovery provides an opportunity to determine service providers that can be included in a composition, whilst substitution is useful for existing compositions where a sub-service needs to be replaced. Lets look at an example. An entity determines that they would like to compose a new service that provides hotel and car rental bookings. An appropriate hotel reservation service, and a vehicle reservation service must be found. The new service is to exhibit the following non-functional properties (1) it is to provide a single settlement model, (2) it is restricted in spatial availability accommodation and car hire in France, (3) it is restricted to service requestors from Australia, (4) the accommodation is rated as greater than 3 stars, and (5) the vehicles need to be restricted to carrying greater than 4 people. The composing entity needs to discover services that meet the specified criteria. To undertake this in a dynamic manner, sufficient functional and non-functional information must be included with its published description.

5.4 Management

Rich repositories of service metadata provide an opportunity for monitoring and controlling the operations that occur on that metadata (e.g. discovery, substitution, composition, execution). Existing service management architectures that support composition include Aurora and DySCo [44, 54]. We suggest that any service management architecture that aims to monitor or control service life cycle operations will need to recognise these operations by means of a rich service description language. However, such a system will need to do more. These systems may be relied on to establish that the behaviour of a service, as delivered, is consistent with the service as specified in a contract is a highly important issue. *Conformance* may have legal consequences. How can it be demonstrated, by examination of a trace or otherwise, that a service was or is being properly delivered?

Additionally, service management repositories offer opportunities for the development of comparative tools that evaluate services "side by side" and that are capable of tracking the evolution of a particular service or type of service. As services evolve, consequently their descriptions should also reflect that metamorphosis. Evolution of a service can be the result of (a) interactions with either requestors or service composers, (b) changes to the environment that surrounds a service, (c) the need to alter the functionality, or (d) impetus from the changing constraints or non-functional properties over the service. Mechanisms that implement non-functional properties (e.g. security, trust and channels) will evolve with standards from the relevant domains. Service evolution is likely to be constrained by the existing commitments that service providers have to delivering a service. The need to administer evolving service descriptions questions the need to include expiry conditions (e.g. temporal constraints) within the description. This provides a mechanism for updating cached descriptions. A similar mechanism is provided in HTML metadata.

6 Related work

Current initiatives such as UDDI, WSDL and WSFL are considered complementary to the expression of properties. The functional focus of these initiatives serves to highlight the lack of literature relating to the expression of non-functional service properties. UDDI primarily aims to be a worldwide catalogue for services. WSDL attempts to describe the interface, protocol, bindings and operations of services. WSFL is a workflow-like approach to assembling services. Whilst briefly mentioned and referred to as "endpoint properties", there is yet to be a concentrated effort on this crucial aspect of service description [39]. Interestingly, the functional aspects of services have been noted as similar to existing technologies, WSDL as similar to interface definitions, WSFL as similar to workflow definition languages, and UDDI as similar to OMG's object traders [62]. It seems that the distibuted computing problem is now being tackled from a less risky standardisation perspective, hopefully leading to more success than

technologies that have previously addressed this problem [25].

IBM's Advertisement and Discovery of Services (ADS) protocol utilises a combination of WSDL to describe access mechanisms and an abandoned non-functional description language entitled the Well Defined Services specification [47]. The protocol was to offer two approaches to the discovery of services, one via web crawling (having a well-known XML file containing service information located on the corporate web server) and the other via context (using the inclusion of a meta tag in HTML files). Service descriptions can be singular, for a collection or for a repository. Whilst its use of existing technologies is applauded, this approach still lacks the dynamism required for continually evolving services.

Property description has been attempted using a variant of Corba's Component Definition Language (CDL) [67]. This approach used CDL to express service description, service advertising and service assembly. Separate languages, not expressed in concrete form, are mentioned for requesting services and interacting with them. The paper briefly discusses the need to capture the properties of services but differentiaties concepts such as payment, cost and security from other service properties (e.g. the service location).

Another associated technology is the Web Services Meta Language by Microsoft. It is an inclusion within their SOAP toolkit that enables the operations of services that have been described via WSDL to be mapped to methods within a Component Object Model (COM) object.

7 Conclusions

Whilst acknowledging the importance of the functional properties of services, this paper has attempted to highlight the issues associated with non-functional service properties. Within this paper we have taken the view that service description is only complete once the non-functional aspects are also expressed. We believe that the ability to richly and accurately describe services has applicability in the areas of electronic service discovery, substitution, composition and management. The increased level of service property information also facilitates more thorough decision-making by a service requestor. This paper has been motivated by the everyday services that surround us, and the ways in which we engage with them. We believe that the historical interactions, both social and economic, of commercial services offer strategic insight for the success of electronic service initiatives. We believe that an abstract service property description language capable of detailed expression will act as a key component for these initiatives. The ideas discussed in this paper can provide a basis for the development of such a language.

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Table 1: Dimensions of payment instruments.

Payment Instruments	**Payment Dimensions**											
	Offline	**Online**	**Acceptability**	**Traceability** [2]	**Non-refutable**	**Negotiability**	**Liquidity**	**Expiration**	**Provider Coupling** [3]	**Transferability**	**Security**	**Immediacy**
Cash	◇ [1]		H	◇		◇	H			◇		I
Cheque	◇		H	◇		P [4]	M	◇	◇	◇		D
Direct Funds Transfer		◇	H	◇	◇	◇			◇	◇	◇	I
Credit/Charge Card	◇	◇	H	◇			◇		◇	◇		D
Traveller's Cheque	◇		M	◇	◇	◇	M			◇		D
Wire Transfer	◇		L	◇	◇		M					D
Money/Postal Order	◇		L	◇	◇		M					D
Security	◇	◇	H	◇	◇		M		P			D
Bond	◇	◇	L	◇			H			◇		D
Bank Bill	◇	◇	L	◇			H			◇		D
Voucher	◇		M	◇		P	H	P	◇			I
Stored Value Card	◇	◇	L	◇			L	P	◇			I
Digital Cash		◇	L	◇	◇		L		◇	◇	P	I
Anonymous Digital Cash		◇	L		◇		L		◇	◇	P	I

[1] Subjective Legend : P = Possibly, H = High, M = Medium, L = Low, I = Immediate and D = Delayed. ◇ indicates the dimension is applicable to the payment mechanism.

[2] Traceability has varying degrees. Face-to-face cash transactions have a degree of tracability. However this type of transaction could also be conducted on behalf of someone else (e.g. by giving money to someone to buy something for you).

[3] Coupling includes items such as accounts, passwords, and personal identification numbers.

[4] Cheques can be marked "not negotiable".