Utilization of Faceted Classification in the Context of the SWIM Service Registry

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Abstract

The proliferation of SWIM-enabled services in the FAA NAS environment has led to a rapid increase in the volume of service metadata being stored in and shared by the FAA's NAS Service Registry/Repository (NSRR). To provide discovery and retrieval mechanisms better suited to match consumer needs with capabilities offered by the services, NSRR custodians are enriching existing retrieval capabilities by establishing classification schemes that efficiently support classification of services based on user-defined search patterns.

This paper examines some classification schemes currently utilized in the NSRR and discusses two different types of schemes, hierarchical and faceted. It also proposes three service classification scheme facets based on analysis of popular search patterns and specific characteristics of ATM services in the context of FAA SWIM implementation.

Keywords: SWIM, SOA, service metadata, service registry, faceted classification, taxonomy.

1. Background

In the last few years, as the number of service-oriented architecture (SOA)-based services has increased in the National Airspace System (NAS) and among NAS business and international partners, the term "service metadata" has become prevalent. The concept of service metadata is a logical extension of the concept of metadata, whose direct – although superficial – translation is "data about data". In the contemporary field of information management, this idea has been transformed into something more than just "data about data". Metadata is now seen by industry experts as data describing context, content, and structure of records and their management through time [1], as well as information structures that allow users to retrieve, use, or manage an information resource [2]. By adopting this

view in the context of SOA, and also extending some other well-recognized industry definitions of metadata (see [3], [4], and [5]), we define *service metadata* as structured information and/or documentation that makes a service discoverable, accessible, usable and governable throughout the service lifecycle.

When service metadata is placed in a special repository commonly called a service registry, it enables discovery of services via query capabilities provided by the registry. The NAS Service Registry and Repository (NSRR) is a System Wide Information Management (SWIM)-supported capability for making services visible, accessible, and understandable across the NAS [6]. NSRR uses a formal registration process to store, catalog, and manage metadata relevant to all *SWIM-enabled services[1].*

To facilitate service discovery and governance processing, the NSRR deploys a set of taxonomies mostly defined in FAA Standard Practice FAA-STD-066, Web Service Taxonomies [7]. FAA-STD-066 defines taxonomy as a hierarchical organization of categories or values used for classification. In this paper we argue that all taxonomies derived from this standard and currently utilized in the NSRR should be considered, and subsequently used, as *hierarchical classifications*. We contend that some of the taxonomies (current and future) should be utilized as *facets* in the context of *faceted classification* schemes.

2. Service Metadata Classification Schemes

For the purpose of our discussion, we first need to establish the following terminology:

A *hierarchical* classification scheme is a structure containing concepts or categories ("nodes") that are linked together through parent/child relationships with at most one parent node for each child node, and with only one root node. The root node represents the most general category, and each subordinate node represents a more specific concept or category than its respective parent node.

A *facet* comprises clearly defined, mutually exclusive, and collectively exhaustive aspects, properties or characteristics of a class or specific subject [8]. Every facet has a *name* (e.g., Message Type) and every category within the facet is identified by a *label* (e.g., Text, Stream).

A *faceted* classification scheme is a set of mutually exclusive and jointly exhaustive categories, each made by isolating one perspective on the items (a *facet*), that combine to completely describe all the items in question, and which users can use, by searching and browsing, to find what they need [9].

The difference between *hierarchical* and *faceted* classification is that the items are **placed into** a hierarchical scheme, whereas facet labels are **assigned to** items [10].

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[1] A SWIM-enabled service is a SOA-based service that uses SWIM common computing and infrastructure assets.

3. Usages of Classification Schemes

Both hierarchical and faceted classification approaches have been used in the FAA and more specifically in the NSRR, although their conceptual distinction has not been clearly pronounced. In this section we elaborate on their usage in the context of SOA services in the Air Traffic Management (ATM) domain.

3.1 Hierarchical Classification

The first example describes a hierarchical classification scheme that uses the FAA Service Category Taxonomy described in section 5.3.5 of FAA-STD-066 [7]. The stated purpose of this taxonomy is to provide a single standard system for categorizing FAA services by the type of service provided. The main concept of this taxonomy is "service category". The *root* of this taxonomy is "FAA Service" with the categories of various FAA services being the child nodes. (Only nodes relevant to our example are denoted here.) For the purpose of this exercise we will locate (navigate to) Notice to Airmen Service. As Figure 1 illustrates, to locate this service we have to start at the FAA Service root node and then "drill down" to Air Transportation Information Service and continue to drill down through subsequent nodes until we arrive at the goal of our search.

Figure 1 Example of hierarchical classification

A point to note is that if we were to add another category anywhere between root node and Notice to Airmen Service, it would inadvertently change the associated search pattern. In other words, it would change the relative position of the targeted item (and its subordinate items, if any) in the context of the classification scheme.

3.2 Faceted Classification

For an example of faceted classification, we will use the following three facets: ATM Service, SWIM Service Product, and Service Interface Type. Section 4 of the paper elaborates on the design and content of each facet, but for this example it is sufficient to know that ATM Service consists of Flight Planning, Airport, Arrival and Departure, En Route Cruise/Oceanic, and NAS Management services (not shown); SWIM Service Product consists of Aeronautical, Flight, Navigation, Surveillance, Operation and Maintenance, and Weather products; and Service Interface Type consists of Method-oriented, Message-oriented, and Resource-oriented types of interfaces. Here again we will be searching for a Notice to Airmen Service (which in the context of SWIM is realized as "FNDS" for Federal NOTAM Distribution Service). We will begin our example by asserting that FNDS has been "tagged" (labeled), using the values defined in the first two facets, as a service that supports strategic Flight Planning ATM services and provides an Aeronautical data product. Then it can be said that FNDS is to be "found" at the intersection of these two facets as depicted in Figure 2.
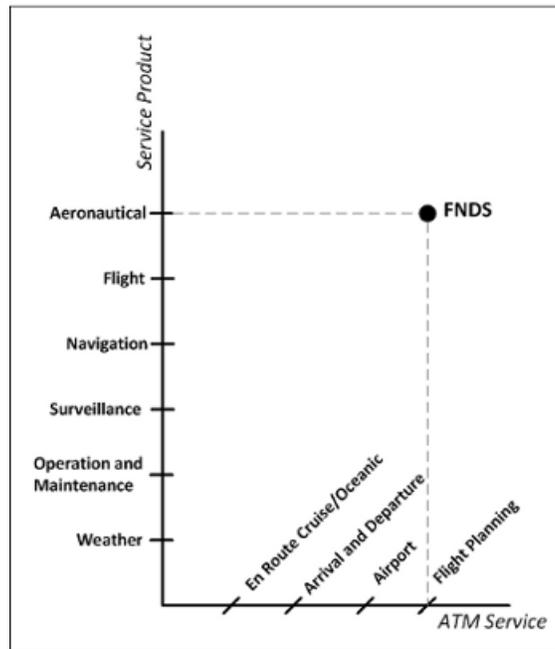

Figure 2 Example of faceted classification with two facets

We can extend this example by adding another facet to this classification scheme, Service Interface Type, which allows categorizing the service by the type of interface it offers to a service consumer. If we assert that FNDS is a Web Service, and as such has been tagged as method-oriented, then it could be discovered at the intersection of all three facets as shown in Figure 3.
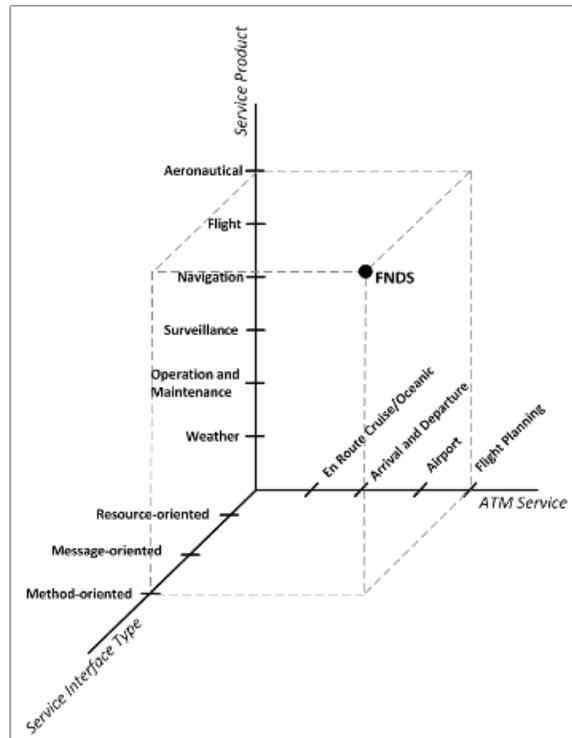
Figure 3 Example of faceted classification with three facets

The examples of faceted classification raise three points worth noting:

- It is possible to add any number of facets, as long as they represent some characteristics of the item being sought. For example, if we add a fourth Service Lifecycle Stage facet (Proposed, Definition, Development, Verification, Production, Deprecated, Retired), we could refine our search even further to select the services that have been identified as being in a specific stage of implementation.
- It is possible to assign more than one value of a given facet to a service. I.e., a SWIM-enabled service may provide more than one category of products, support multiple ATM strategic services, and offer more than one interface (e.g., some NAS business services offer two types of interfaces: method-oriented as Web Services and message-oriented as Java Messaging Services). At the same time, a service cannot be labeled with more than one Service Lifecycle Stage facet value.
- Adding a facet to a faceted classification scheme is only possible where an associated characteristic of the item in question -- in our case a service -- has been established; that is, the ability to create a new facet is determined by the architecture of the service deployed in a given registry. Because of this, adding new facets may require changes to the service model and/or registry storage structure.

4. Experimental Design of Individual Facets

In our earlier examples of faceted classification scheme usage, we introduced three facets: ATM Service, SWIM Service Product, and Service Interface Type. Here we describe the facets in greater detail and explain their derivation. We emphasize that these facets apply to the classification of SWIM-enabled services.

4.1 ATM Service

The design of this facet is derived from the conceptual vision established by the Next Generation Air Transportation System (NextGen) and further elaborated in the *FAA/NextGen Mid-Term Concept of Operations for the National Airspace System* [11]. We define *ATM services* as services implemented in and operated by the National Airspace System (NAS) for the purposes of supporting the safe, orderly, and expeditious flow of air traffic. We assert that each SWIM-enabled service is a realization of one or more strategic ATM services shown in Figure 4 [11].
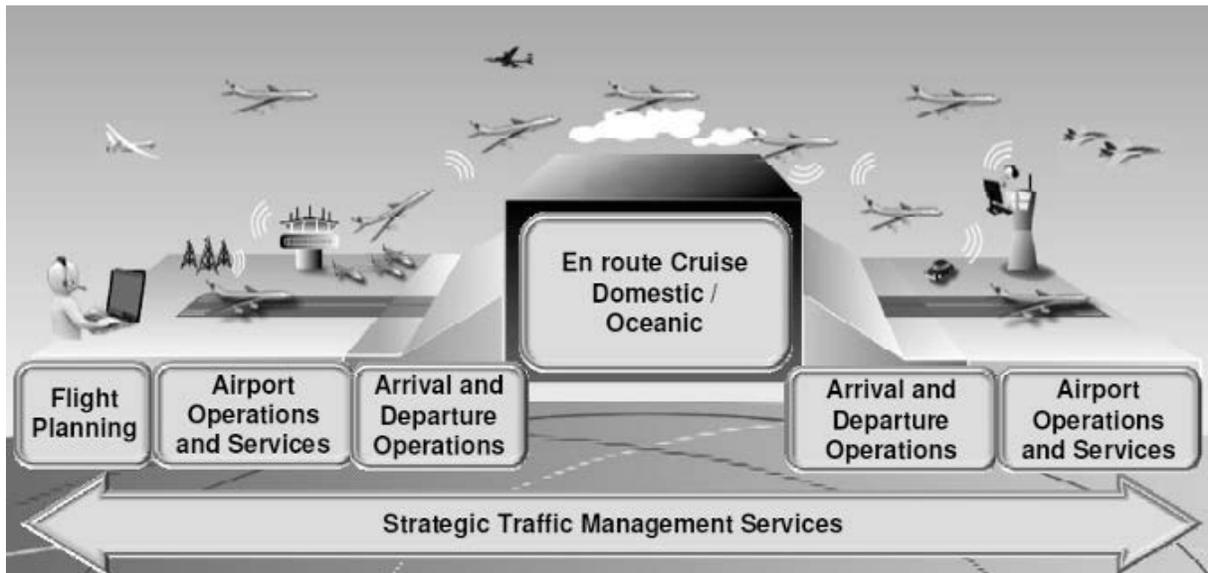

Figure 4 Strategic Traffic Management Services

Label	Definition
Flight Planning	Operations and services that support the entry, update, and management of information that describes an intended flight or portion of an intended flight of an aircraft.
Airport	Operations and services that support the control of aircraft and vehicles on the airport surface. Such operations encompass movement from the gate or ramp to the runway at the departure airport and from the runway to the gate or ramp at the destination airport.

Arrival and Departure	Operations and services that support the control of aircraft in arrival and departure airspace, including departure operations to top of climb, arrival operations from top of descent to the airport surface, and transition flights.
En Route Cruise/Oceanic	Operations and services that support the control of aircraft in that part of a flight in which aircraft are generally level at cruise altitudes, whether in domestic cruise airspace or oceanic airspace.
NAS Management	Operations and services that support the function of monitoring the NAS and taking appropriate action when abnormalities are detected.

4.2 SWIM Service Product

By analyzing user requests for information available in the NSRR, we infer that one of the major characteristics of a service, from a consumer's perspective, is the data product provided by the service. The SWIM Service Product facet addresses this need by providing major categories of products produced by *SWIM-enabled* services. We define *product* as an identifiable collection of data which can be delivered in the course of execution of a service.

Label	Definition
Aeronautical	Data used to describe, manage and control aeronautical facts, concepts or instructions such as special use airspace restrictions, airport configuration, and Notices to Airmen (NOTAMS).
Flight	Data used to describe, manage, and control the safe movement of aircraft in the NAS, including information such as flight itinerary, flight identification, flight planning, flight events and status, and Air Traffic Management (ATM) control events that affect a single flight.
Navigation	Data used to locate the position and describe the course of aircraft.
Surveillance	Data produced by technologies (e.g., radar, beacon interrogator, automatic dependent surveillance-broadcast) for detecting and locating airborne and taxiing aircraft and ground support vehicles.
Operation and Maintenance	Data used to describe the status of communications and other equipment, systems, facilities, and maintenance schedules and requests.
Weather	Data used to describe current or predicted atmospheric conditions, including terminal and airborne weather observations, forecasts, and reports of weather phenomena.

4.3 Service Interface Type

Another important characteristic of a *SWIM-enabled* service is the type of interface exposed by the service to a service consumer.   The Service Interface Type facet allows classifying a SOA service based on the type of interface that the service offers.

Label	Description
Method-oriented	An interface that exposes service capabilities through a set of operations. Technologies that support this interface type are Web Service framework (WS*) and OGC Web Common Services.
Message-oriented	An interface that exposes service capabilities through creating, sending, receiving, and reading messages exchanged by distributed systems. The middleware technologies that support this interface type include Java Message Service (JMS) and .NET WCF.
Resource-oriented	An interface that supports the REST architectural style of interactions, that is, manipulation of XML representations of Web resources using a uniform set of stateless operations, usually a set of HTTP methods.

5. Conclusion

Hierarchical classification schemes are information structures designed with a goal of describing relationships among items in a collection. This makes them well suited for the development of taxonomies that present a classification of services within an organization (see for example the categorization of FAA Services discussed in section 3.1) and that lend themselves to "drill down/up" search patterns in a service registry. However, their inherent inflexibility means that their usage in supporting advanced search capabilities in the NSRR is expected to be limited.

Faceted classification schemes are more flexible and robust and allow searching for items in a collection (i.e., services in a registry) in a variety of ways rather than in a single and predetermined hierarchical order. As our analysis and experimental designs demonstrate, existing NSRR service retrieval capability can be improved by introducing searches that are based on a combination of correlated facets.

It should also be noted that while hierarchical classification generally treats a service as an immutable object, faceted classification may require changing the service model by adding or modifying service attributes which will subsequently be exposed as *facets*.

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