Personalisation in German Smart Sensor Web

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Abstract

German Smart Sensor Web (GSSW) is an experimental system for the German Federal Armed Forces. Its purpose is to provide a secure integration infrastructure for networked sensors. GSSW has a middleware based on ontologies and software agent technology. It uses a semantic representation of sensor data and other information in the area of intelligence, surveillance and reconnaissance (ISR) to feed "smart" symbolic AI based assistance functions. Interface agents also use the knowledge representation to personalize different aspects of the user interface. In this contribution the current state of GSSW, its software architecture and the personalization features of the user interface layer are presented.

1 Introduction

Intelligence, surveillance, and reconnaissance (ISR) are important military processes. The aim is to gain battlefield advantage through information superiority. The availability of secure information and communication networks results in the request for the collection, merging, and timely dissemination of sensor data and derived intelligence.

Different technological and organizational approaches are possible to achieve such an integration of information sources. GSSW is an attempt to gain empirical evidence for comparing the feasibility and effectiveness of these implementation strategies. GSSW consists of an experimental secure network and a middleware for integrating different kinds of information sources in the area of ISR.

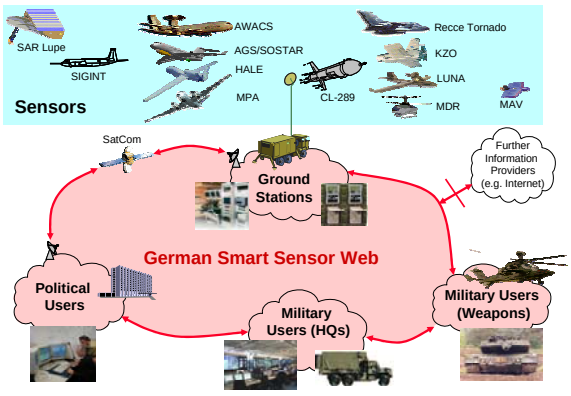

Fig 1: Concept of Operations

The project goal for GSSW is to enable each user to access all reconnaissance information and services relevant for him or her rapidly with the help of support systems. The necessary steps are to identify, access, and retrieve the needed information and to categorize, summarize, filter, and evaluate available information according to the users' individual tasks.

The rough concept of operations (see Fig 1) is that sensors like unmanned aerial vehicles or satellites provide data through their ground stations. Ground stations have databases that store the ISR relevant information to be integrated into the information space of GSSW. Users include political and military users. Users and information source nodes are connected via a secured network. Some nodes in the network do not only provide information sources but also ISR specific algorithmic services either provided by computer systems or human operators.

2 Network

Several locations are connected through the GSSW network. It is implemented as a virtual private network based on the secure internet architecture (SINA [BSI, n.y.]) via the public internet. Currently there are four locations connected in the GSSW. Every location provides information sources, services by users and computer systems. Two locations provide additionally a middleware with user interfaces and functionality for access to ISR services and information. The user interfaces are implemented as web applications and can be accessed from every node with a web browser.

One of the two alternative systems has been implemented by Fraunhofer IITB. The software architecture and its means for personalization are presented in this contribution.

The current implementation of GSSW uses different information sources. They are structural equivalent to operational systems but do not store operational data or are deployed as part of operational systems. Examples for content provided by the information sources are aerial images, intelligence reports, and air reconnaissance tasks.

Examples for services are automated target recognition software for the automatic detection of runways, and services for the conversion of image formats.

3 Software Architecture

The software architecture of the Fraunhofer IITB node of GSSW is based on a semantic representation of ISR information. This representation uses a specific GSSW ontology on ISR concepts. The representation is used to

structure the communicative speech acts of software agents that encapsulate the middleware, provision of services and data access.

3.1 ISR Ontology

Ontologies are linguistic representations of concepts for the knowledge domain. They consist of a description of classes in the domain, relationships between classes in terms of axioms or rules, and a lexicon with syntactic representations of concepts. It is thus a terminology description of domain specific information. Technical it establishes a common vocabulary for agent interaction.

The ISR ontology provides a semantic representation and support infrastructure for high level elements such as ISR objects, ISR processes, and workflows.

3.2 Software Agents

Software agents are a design pattern for cooperative distributed information systems. The GSSW node of Fraunhofer IITB has adopted this design pattern as the basis of the software architecture. It is based on the Java Agent Development Framework (JADE [Bellifemine et al., 2003]). JADE is a development and runtime infrastructure for agent based software systems. It provides good interoperability features through the support for FIPA compliant communications protocols and cooperation language [FIPA, n.y.].

The agents in GSSW are not only deployed as a distributed software infrastructure for cooperative information systems but do also support users in performing demanding tasks in information management.

Features of software agents can be: reactivity, autonomy, cooperation, communication on problem domain level, continuity, deliberative capabilities, adaptivity, mobility, and personality. In a specific implementation only a set out of these features will apply. In GSSW all features except for mobility are met. GSSW-agents are additionally capable of protecting local system resources from unauthorized access.

In GSSW there are agents for accessing information sources and providing services. There are also instances of the interface agent that handle communication with the users and build up their individual user interfaces. The interface agents communicate with the broker agent to achieve the users' information requests. The broker agent knows all resource and service agents and tries to infer a plan to fulfil the interface agent's request.

Fig 2 shows the principal interaction between these agent types. User 1 needs information about airfields in country y. His or her interface agent (1) transforms this to a specific request for the broker agent. The broker agent gets this request via the FIPA ACL using concepts and representations from the ISR ontology. It uses the ontology to make a plan, which agents need to be created or asked to achieve the information request. It builds up an appropriate chain of information resource accesses and services to transform the information. The broker agent knows about all resource and service agents because they have advertised their capabilities according to predefined concepts from the ISR ontology. In the example of Fig 2 there are two agents accessing four different information sources to fulfil the information request of user 1. The broker agent translates the request of interface agent 1 to the appropriate concepts of image agent and report agent. Other users have different instances of the interface agent.

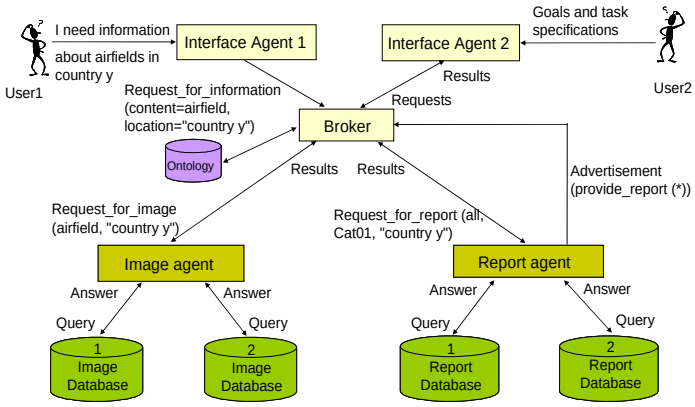

Fig 2: Agent based software architecture

4 User Interface

The user interface of GSSW is targeted at information access and information management in large collections of ISR data. Thus the specific demands of information management in ISR are to be met:

- access to different object types: experts, tasks, reports, maps, images,
- with different methods: push, pull, post before process, subscriptions to new information
- support through functions: zoom, pan, overlay, annotations, mail, chat
- retrieval of ISR information with spatial, temporal, spectral, object specific and free text characteristics
- filtering and selection of information on relevant ISR objects according to user, role, and task

Fig 3 shows a screenshot of the user interface of GSSW. In the centre is a dynamically rendered map. Relevant ISR objects with spatial features are presented as pin points in the map (e.g. reports). Aerial images are shown georeferenced with their foot prints. On the right bottom is an area with buttons for activating tools associated with the map. On the left side is a navigation menu for activating functions.

On the centre bottom is a time scale. Most ISR objects have a timestamp besides their spatial features (e.g. the time when an aerial image was taken or the date of the source for a report). The time scale shows a time-oriented view onto ISR objects. It can be used as a filter to select which information should be displayed spatially in the map.

GSSW features a set of smart support systems that are based on the semantic representation of ISR information. Examples are

- ontology based full text search engine,
- rule-based information fusion,
- automatic annotation in images according to reports.

5 Personalization

Personalization in GSSW does not only apply to the layout and features of the user interface but affects also the internal functioning of the software architecture. It is based on user profiles.

Fig 3: Screenshot of main GSSW user interface

5.1 Profiles

The user profile consists of information about role, tasks, environment, and preferences. Preferences about language, areas of interest/responsibility (spatial as well as temporal) for information access can be modified by the user. Role and tasks affect information access authorization and can thus be modified only administratively.

Users can specify their own preference of different features of services that affect the choice of equivalent available services. Three measures can be given for every available service group: quality, time needed and price.

The quality of individual services is rated by their providers and also by the users. The actual quality is computed as the mean value of the service profile resulting from all individual ratings.

5.2 Adaptive User Interface

Interface agents generate a web-based user interface individually for their respective user. Since the role and tasks of a user specify the needed functionality this information is taken to generate the appropriate navigational aids and tool palettes in the user interface. The preferences also define the area of interest presented in the user interface (map and time scale).

5.3 Adaptive Service brokering

The software architecture of GSSW is based on software agents. Each agent provides services to all other agents. On the basis of a user's interaction an interface agent informs the broker agent of a new goal that has to be achieved. The goal can be to resolve a specific problem or to fulfil a complex information request. The broker agent has information about all capabilities of all other agents. It uses the ontological representation of the capabilities and matches it with the new request. The result is a plan in which sequence agents have to combine their services.

There can be alternative agents (possibly at different locations in the GSSW network) that provide similar services. Since the cost-benefit ratio of different service providers can differ an algorithm suggests the optimal choice to the broker agent. The algorithm takes the users preferences on relevant service features for the appropriate service group into account. The broker agent thus generates a user specific sequence of service providing agents to achieve the goal of the interface agent.

5.4 Information management

Access to information in networked information systems is possible in different ways: Users can push information or meta-information to a public pool and users can pull relevant information from the pool through a search engine or browsing. GSSW allows for an additional personalized way to access the pool. Users can create subscriptions that use the ISR ontology to describe what information in the public pool is of interest to them. A new agent is generated for every subscription that acts as a watch dog and informs its user either asynchronous via SMS or synchronous through a system internal mail box when new matching intelligence products arrive in the pool.

6 Conclusions

GSSW is an experimental system to test information management approaches for handling military intelligence. It has user profile based personalization features that affect the presentation of the user interface and agent interaction.

The latter is a core capability for future service oriented architectures (SOA). Current implementations of SOA infrastructures rely on manually coded static service composition to implement complex business processes. A more flexible and user centred combination of services is needed. The demonstrator GSSW shows a new approach to resolve a complex service request dynamically based on user and service profiles as well as on cost-benefit models.

The use of ontologies and semantic web services is a prerequisite for such future adaptive service brokering and user model based combination of services.

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