Releasing your potential

Managing Knowledge within Space Data Systems

GSAW, March 2009

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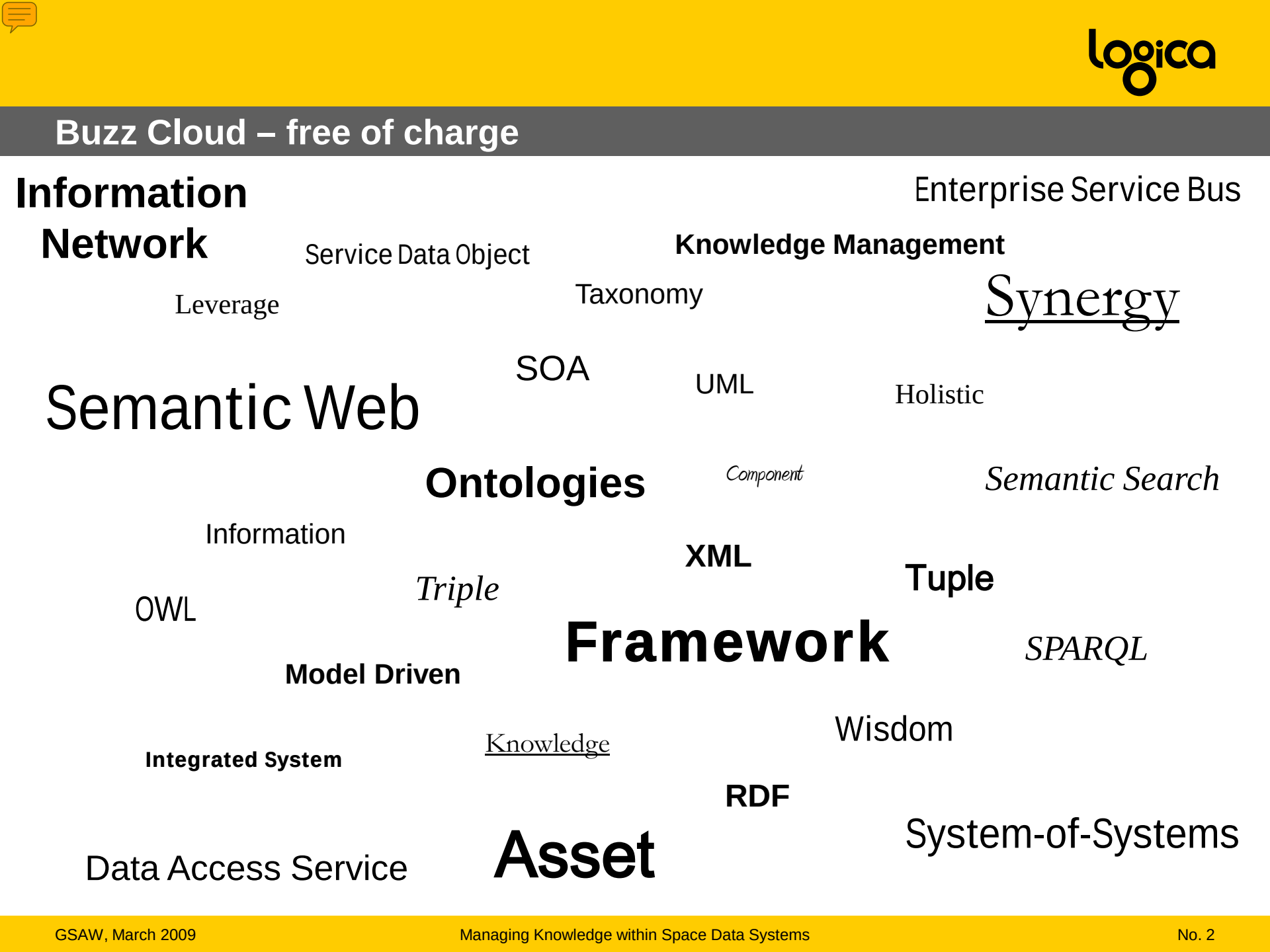


Background

The ESA Exploration Architecture project analysed the possible European architectures for space exploration.

Logica as part of the Space Red team and Surface Blue team analysed and defined the knowledge management sub-architecture, as well as the lunar surface operational scenarios.

The knowledge management subarchitecture has been analysed and defined using the UK Ministry Of Defence Architectural Framework (MODAF), derived from the US Department of Defence Architectural Framework (DODAF).

This presentation describes the results of the analysis and provides a high-level overview of the architecture (vapourware). Based on these concepts a system for support of mission operations is being build (real system).

Message

1. Knowledge is the key value for space manned. Knowledge for mission planners and operators, and knowledge of scientific and commercial value to the end user.

2. The information needed is available today. It’s just disjoint and correlation is manual.

3. The information can be integrated into a holistic view of the mission.

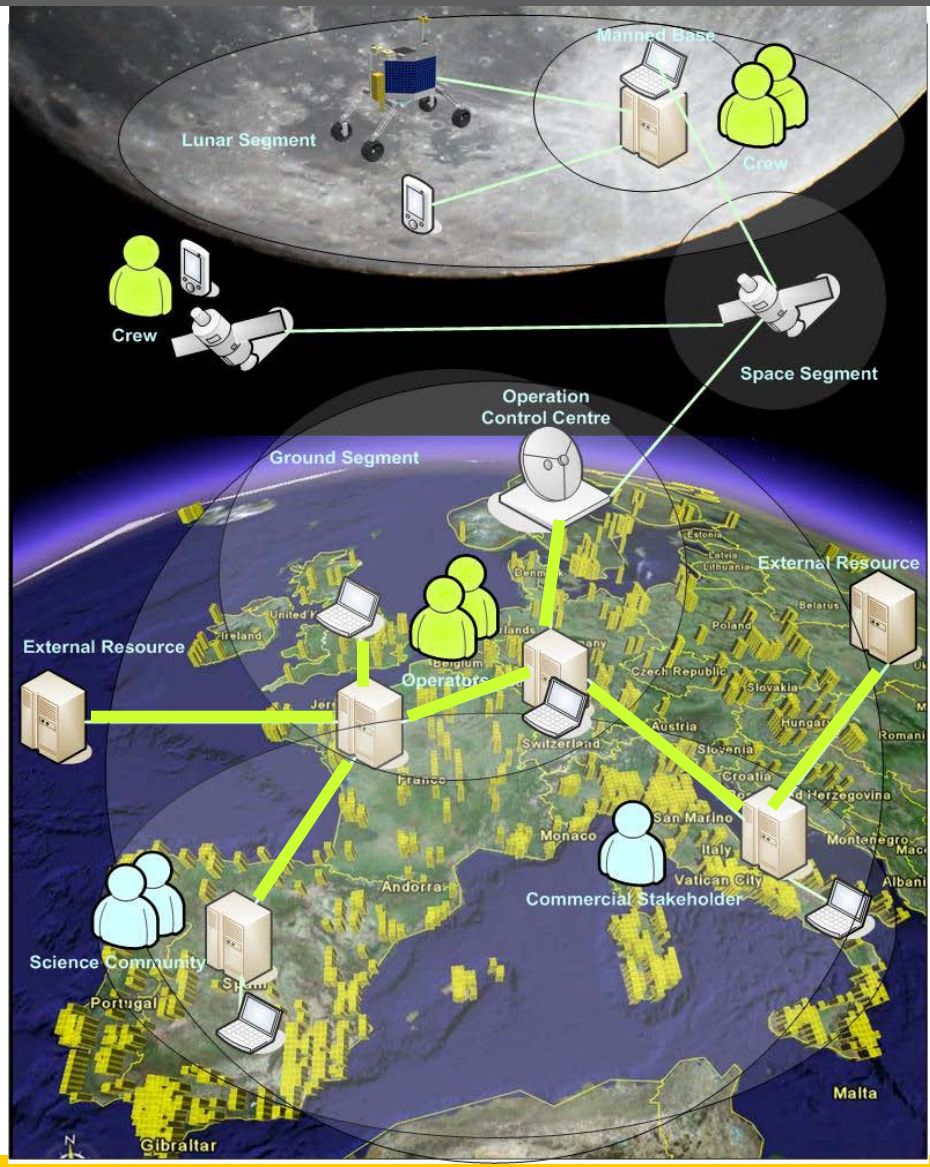
4. This can be done based on standards and technologies available today. The key enabling technologies are RDF / OWL.

5. The implementation can be done incrementally within the system-of-systems in a non-invasive manner.

6. The system is not limited to a specific phase of the mission. It can be used within and to integrate all phases across all organizational boundaries.

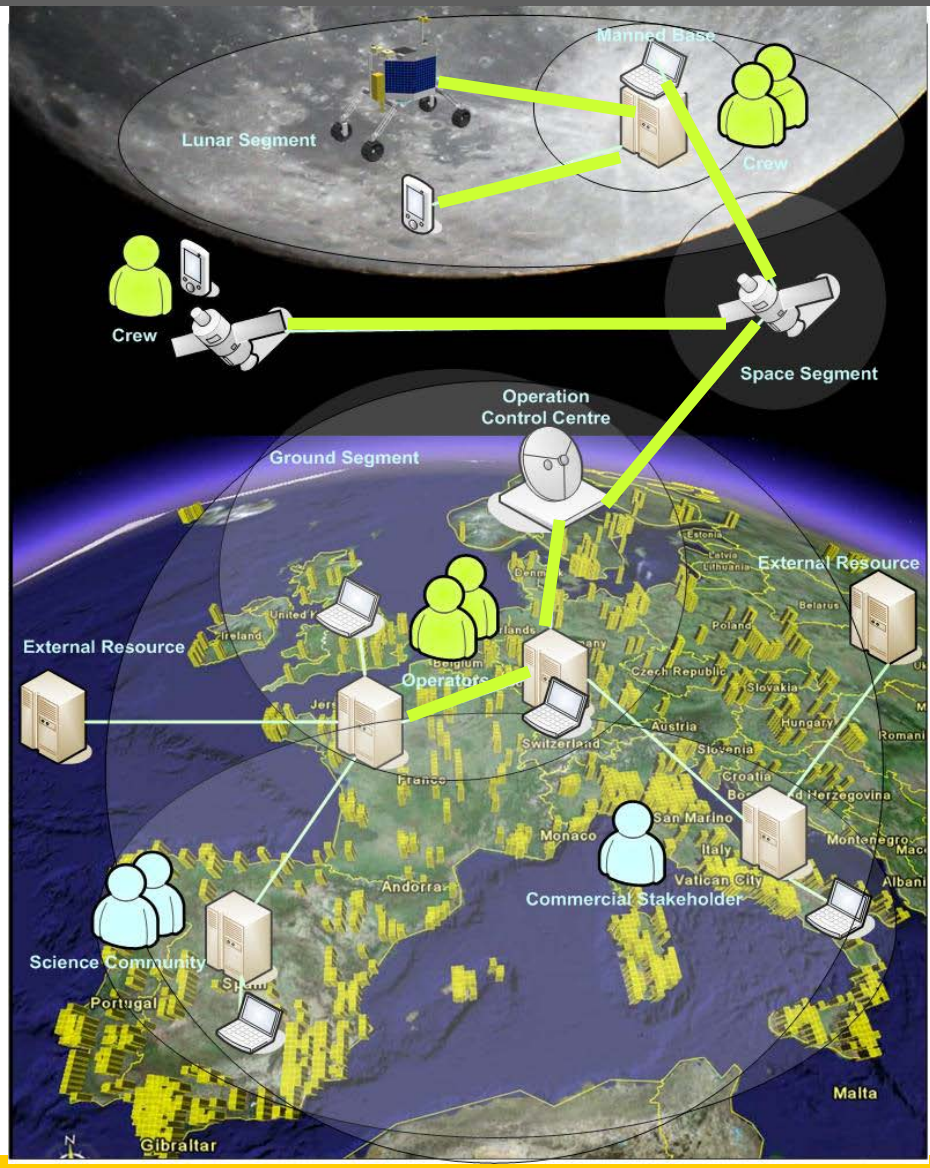
Consider the Challenges of the Mission Planners

- The people within the organisation as part of their daily work add information and knowledge to the organisation
  - Project management.
  - Metrics (performance, cost, etc).
  - System documentation (SRS, ICD, ADD, etc).
  - Process documentation (MPR, MOM, etc)
  - Fact sheets (wiki, lessons learned, technical notes, etc).
  - Communication (emails, instant messages, discussion forums, etc).
- Over decades…
- As part of different phases…
- In different projects…
- Done by different groups…
- Using different formats…
- And different concepts



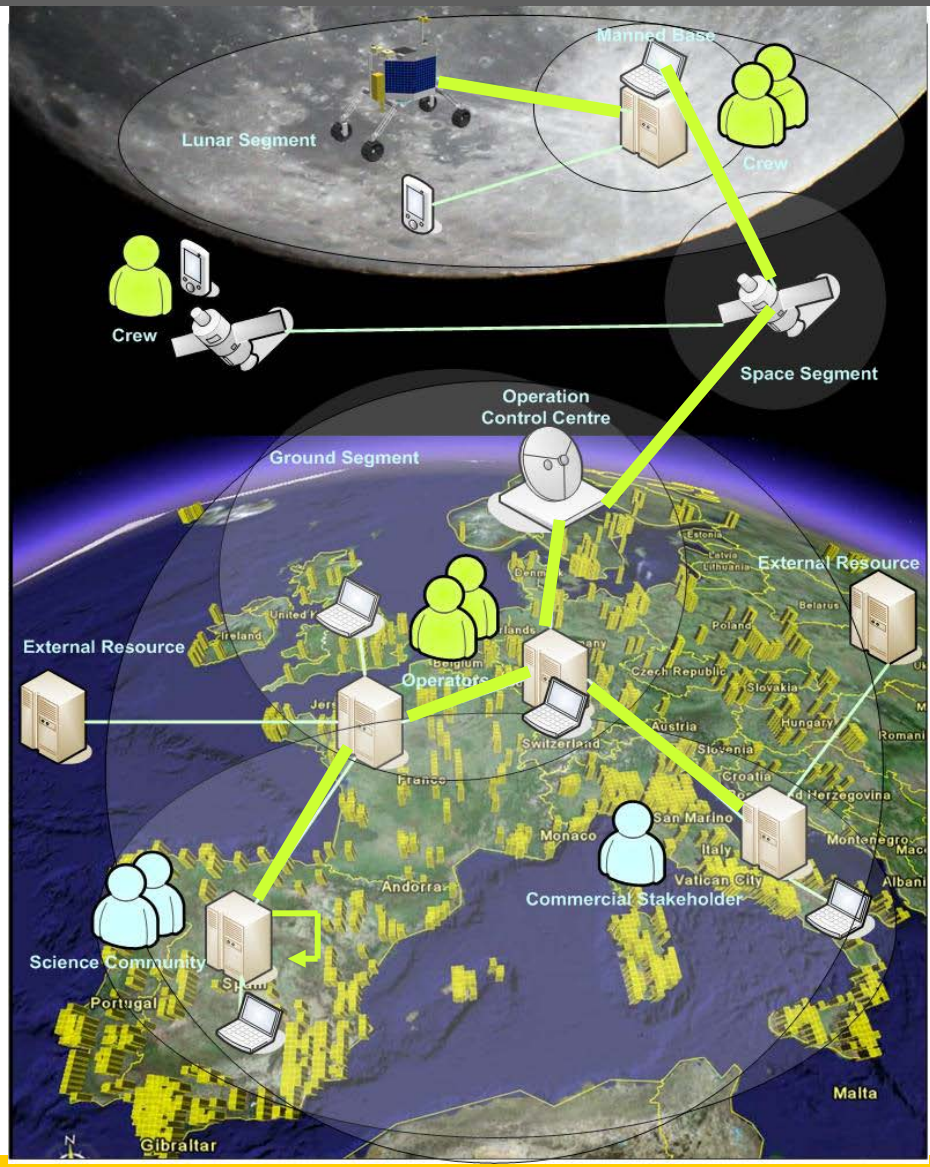
Consider the Challenges of Operational Control

- Enormous amounts of data collected.
- Some types of monitoring involves different systems.
- Using different formats…
- And different concepts.



Consider the Challenges of the end Users

- A need to react to new discoveries and ideas in a timely manner.
- Static information models…
- And fixed interfaces.



What Does these users Want?

- Help.
- Answers.

The Classical Solution

Just

- Build the perfect UML information model.
- Define new procedures, management plans and Frameworks.
- Expect everyone to follow these.
- Build a data provisioning layer using for example SDO + DAS.

… which all too often fails because

- No expert exist that understanding and can model all domains.
- The model become enormous, trying to take everyone's special needs into account.
- Getting consensus for the model is very hard.
- Maintaining the model becomes the main task, not using it.
- The user don’t understand it anyway.
- The teams want control of their domain.
- ++

To the rescue

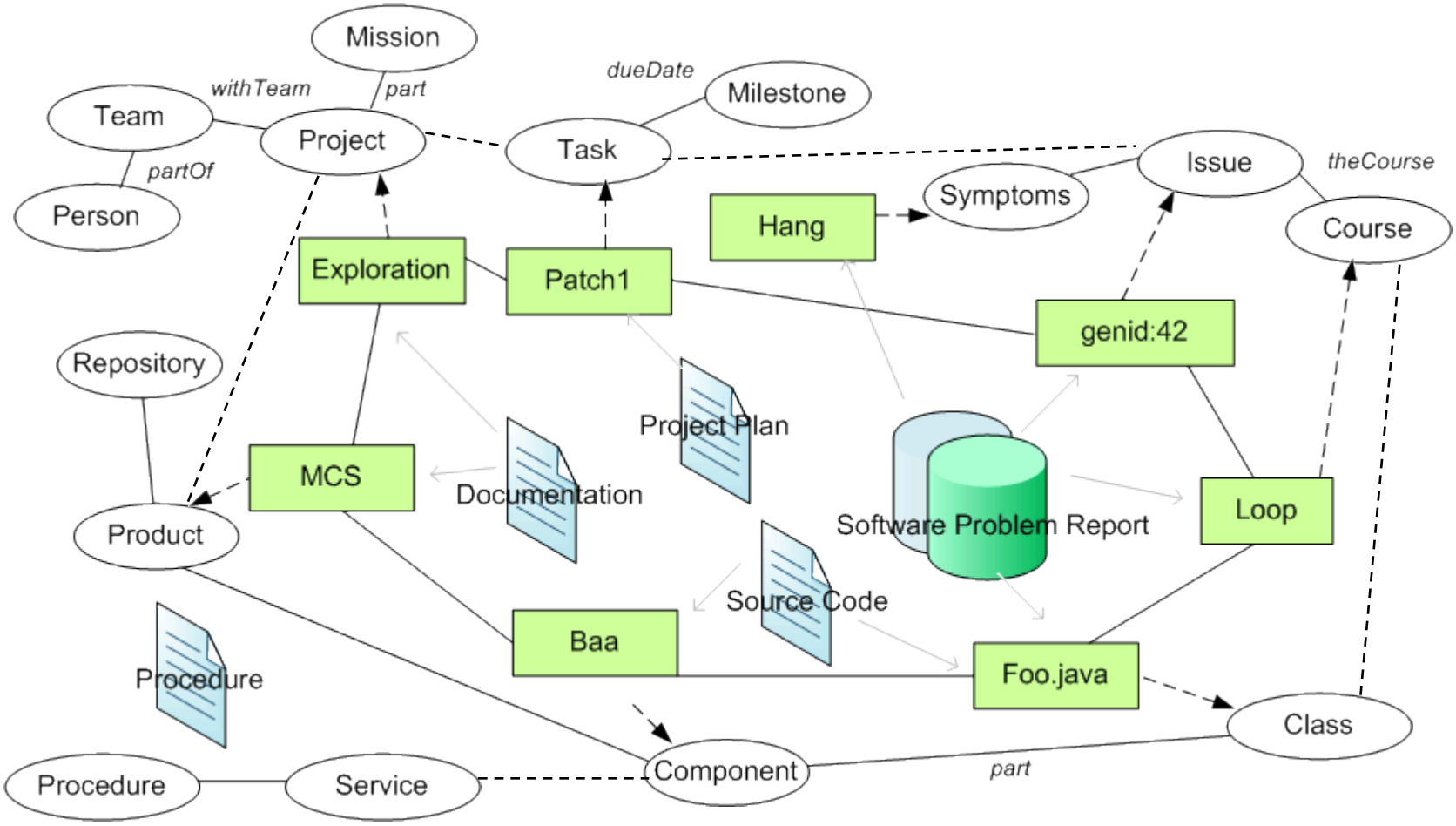
Common problem, already solve.

- Standards
  - W3C Resource Description Framework (RDF)
  - W3C Web Ontology Language (OWL)
  - W3C SPARQL (“SQL for semantic web”)

- Ontologies (“Definition of objects and how they relate to each other”)
  - Friend of a Friend (FOAF)
  - Bug Ontology Model (BOM)
  - Description of a Project (DOAP)
  - Space System Ontology
  - …

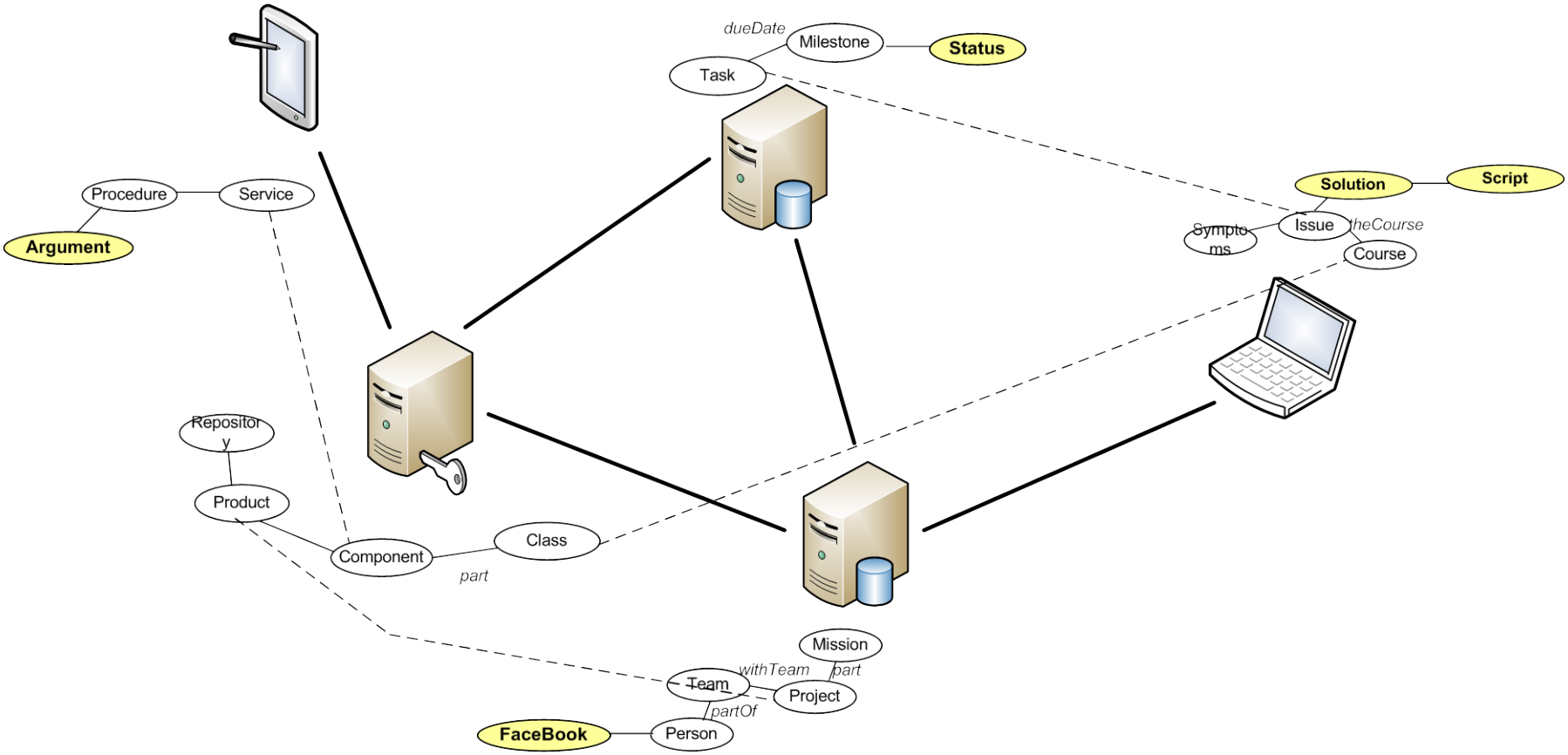
An Information Network

- All building blocks are triples (subject-predicate-object) relationships.



Why is this Different?

- The information model can be distributed.
- In chunks relevant to a specific domain and which people can understand.
- It is thus loosely coupled and easily extendible.



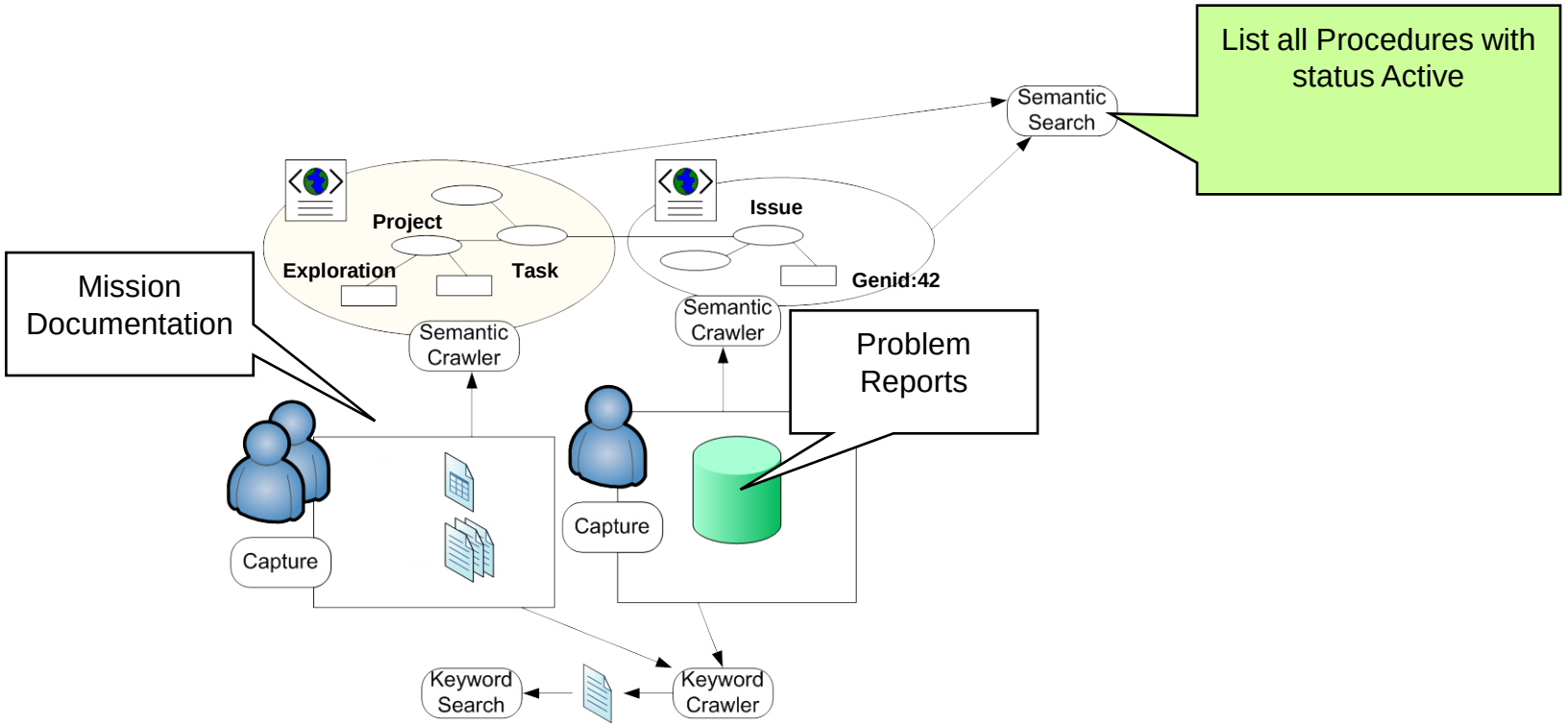
The true Power

.. Is the search and navigation capabilities

- Keyword search
  - “Procedure + Active”
- Semantic search
  - “Procedure with status ‘Active’”
- Tree Search
  - “Give me all connections between an operational procedure with status ‘Active’ and a future task of a project”.
- Users can browse through the information network, following linked notes to the original source.

Building the Information Network

- Define the ontologies.
- Crawl the data.
- Create the triples.

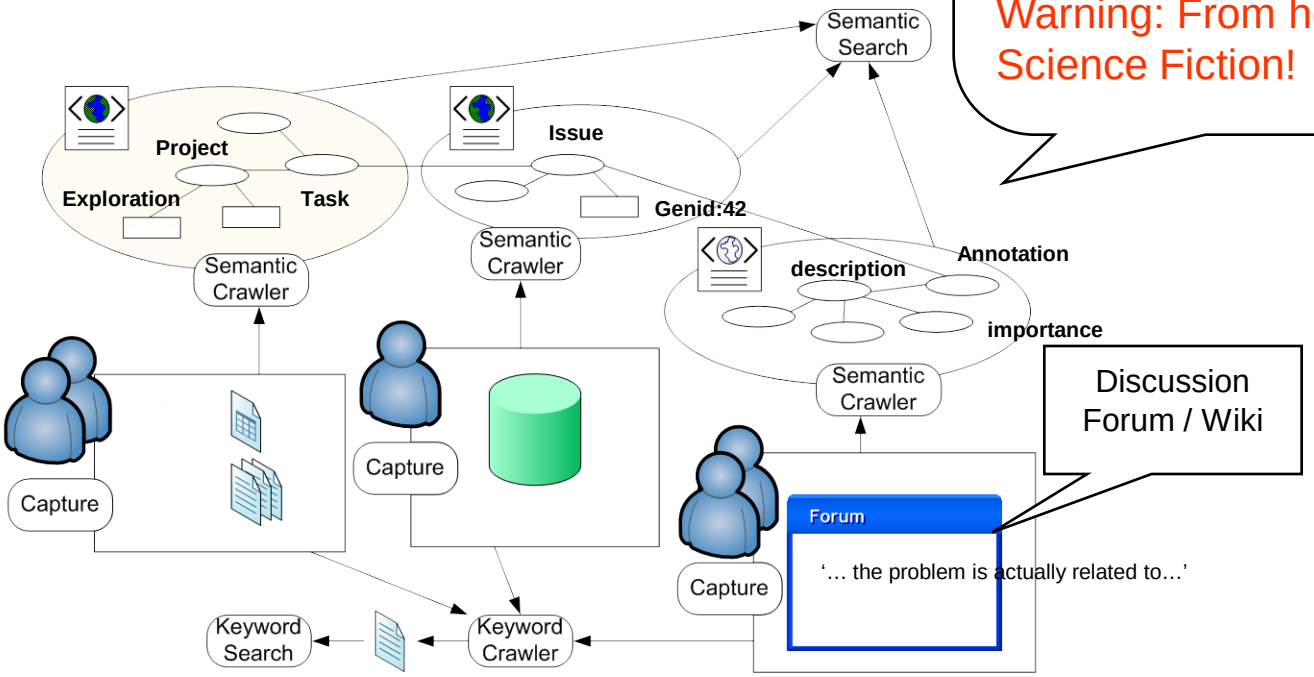


Extending the Information Network

- New data sources can be added dynamically.

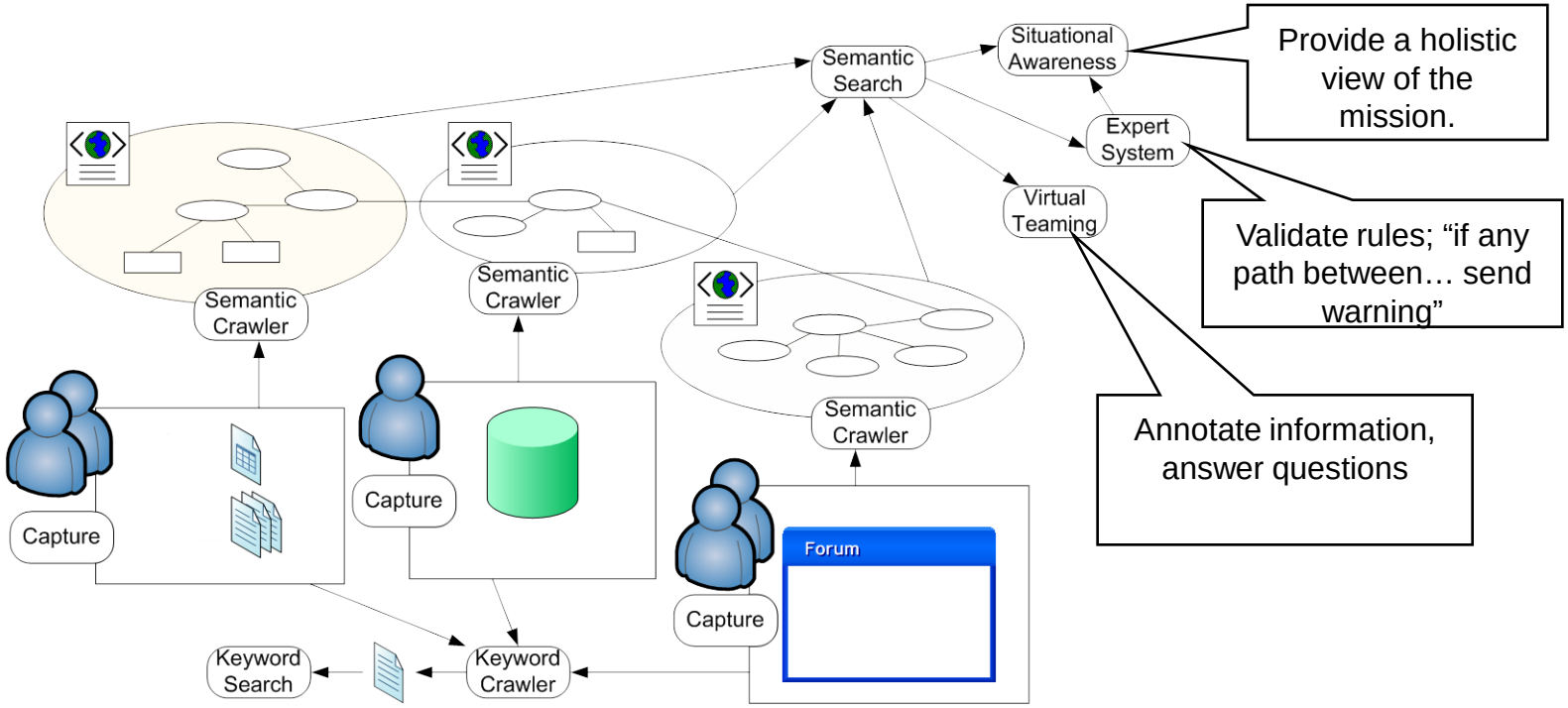
This correspond to the current state of a system being developed for ESA/ESOC.

Warning: From here on its Science Fiction!



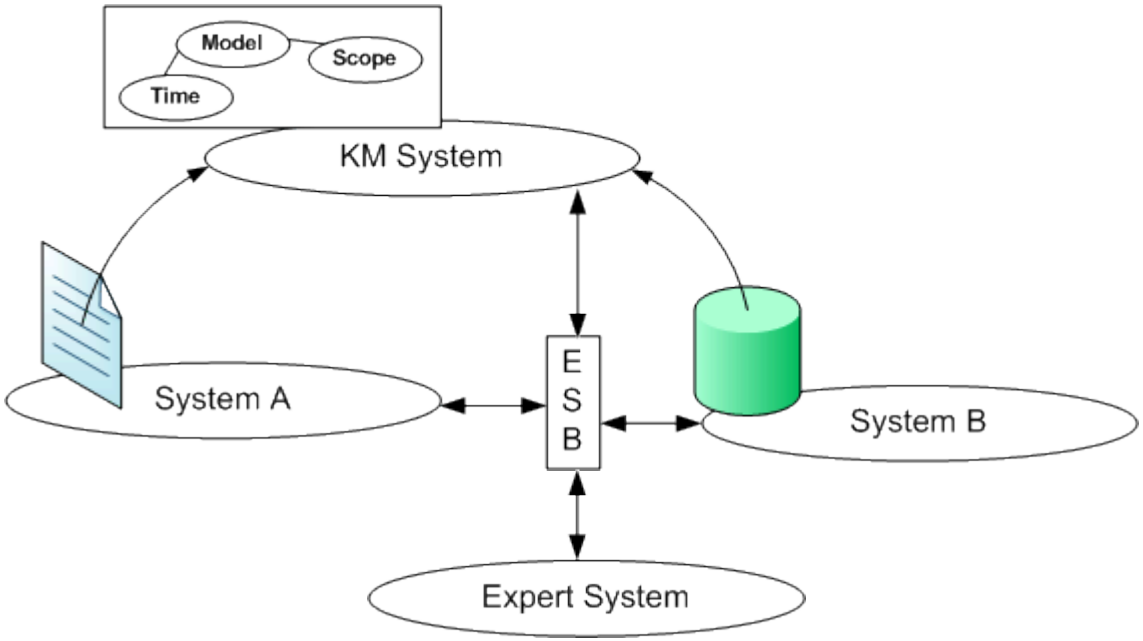
Advanced Systems

- **Expert system**. Continuously monitors the information network based on rules.
- **Situational awareness**. Support timely understanding of one or more contexts to those who take critical decisions.
- **Virtual teaming**. Supports corporation in a distributed environment.



How does this fit in with SOA and the system-of-systems?

- Its just another system.
- It leave the existing system to do what they are best at.
- The KM system reads the information from the other systems, for example through the service interface.
- It exposes its own services back to the ground segment.



Conclusions

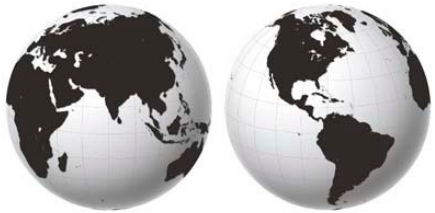
1. This turns complex very fast.
2. RDF and OWL are hard to understand even for experienced developers.
3. Ontologies must be tailored for the specific domain, else nobody understands them.
4. Identify management is a serious problem.
5. Tools are only slowly emerging.
6. Security is an issue not easily solved.
7. This solves a specific set of problems, related to correlation of data across disjoint data sources. No more, no less.
8. … but it solves these problems extremely well.

Questions?

Contact person:

Gert Villemos
Senior Solutions Architect
T: +49 (0) 615136860 147

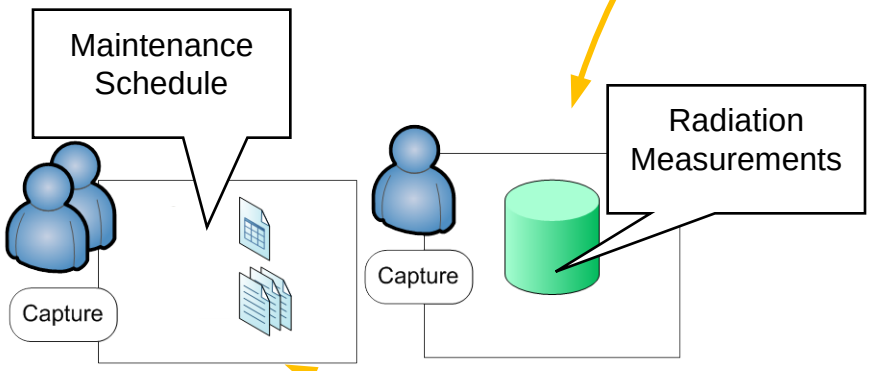
E: gert.villemos@logica.com
www.logica.com

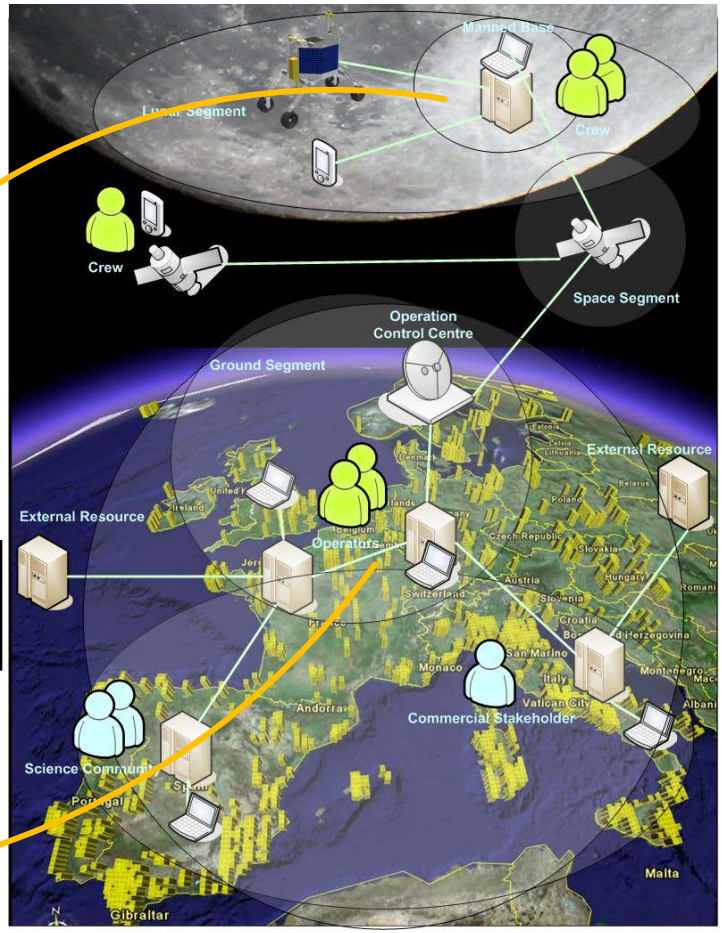


Information System - Capture

Solution

- At each node in the distributed system, information is captured and inserted into the local repository.
- The automatic capture of data ensures that the meta-data needed for long-term persistence of data is available (timestamps, format specification, identification of encoding, etc).
- Crawlers will filter duplicated data and validate consistency.

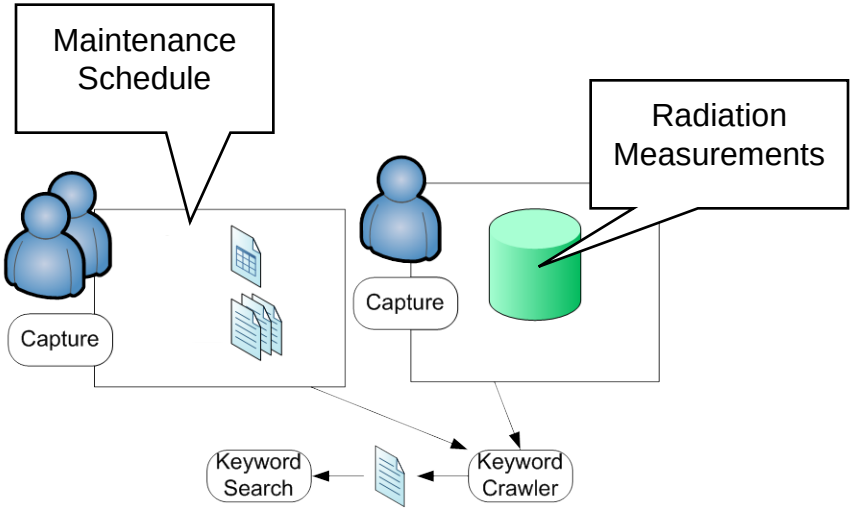




Information System – Keyword Search

Basic Solution

- A network of agents, spanning all segments of the architecture, continuously crawls the repositories and indexes the content based on keywords (= Google).
- Users can perform simple keyword searches across repositories.
- The large physical distribution of the elements within the system-of-systems impose large latencies on data access (in the order of 10s of minutes).
- In addition some elements should be autonomous, capable of operating independently even if communication contact is lost to the rest of the network.



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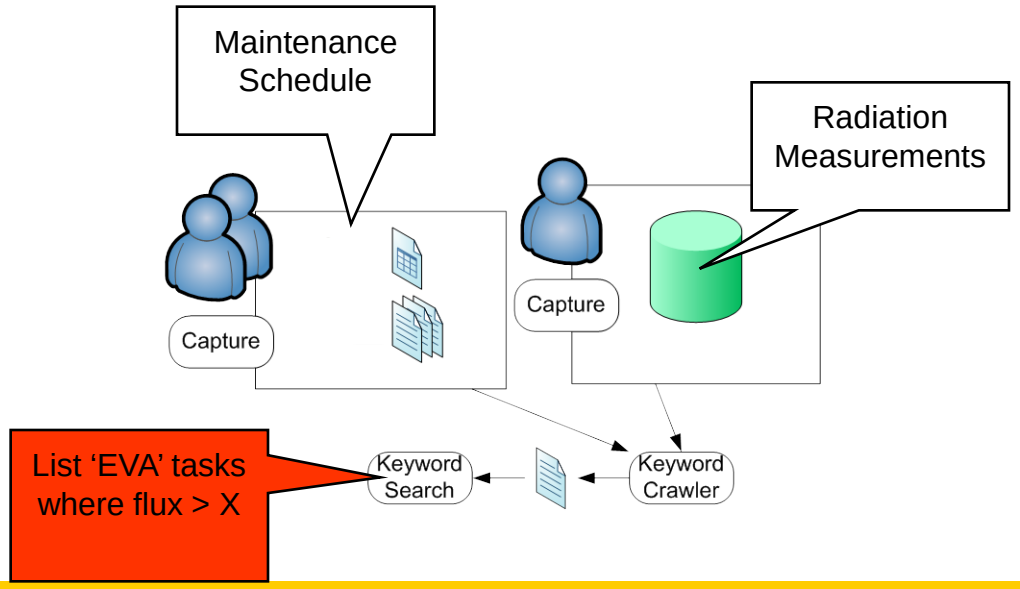
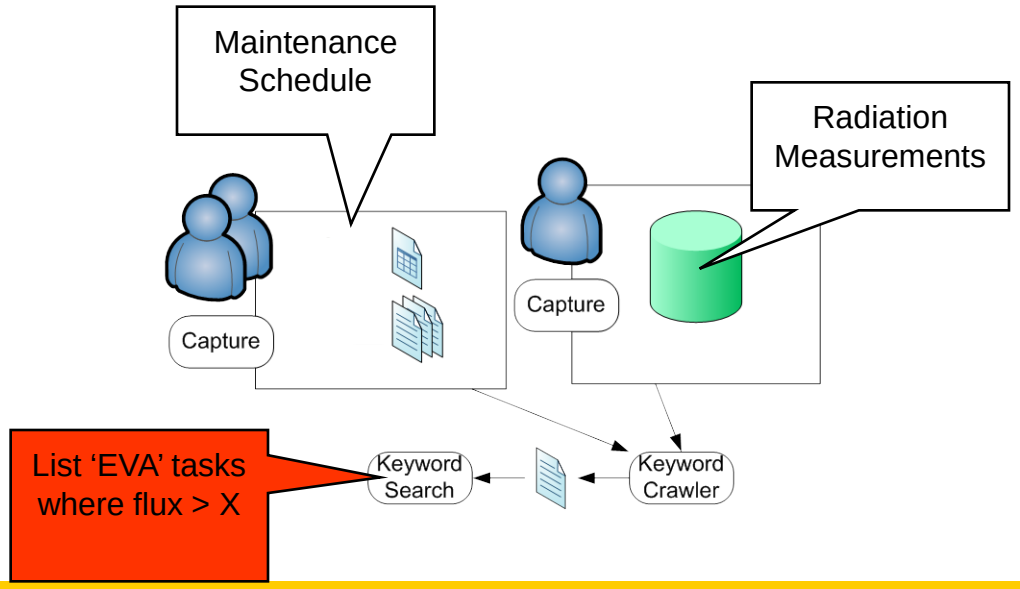


Information System – Keyword Search - Drawbacks

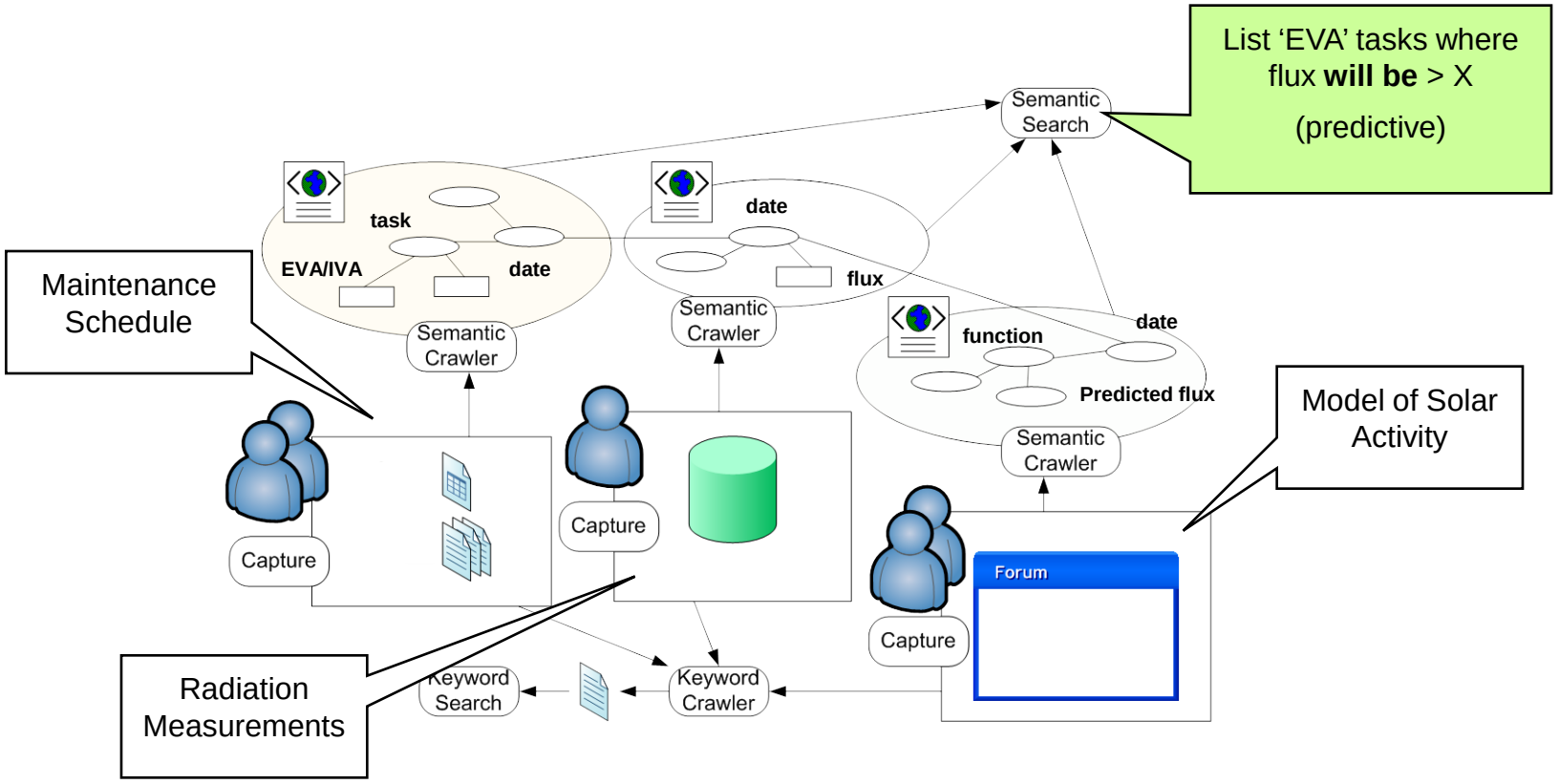
Drawbacks of basic solution

- Correlation of information is manual.
- The same keyword may mean different things in the organisations. Only solution is central reference architecture defining all terms, but therefore also constraining each domain.
- Advanced searches not possible.
- Automatic knowledge extraction not possible.



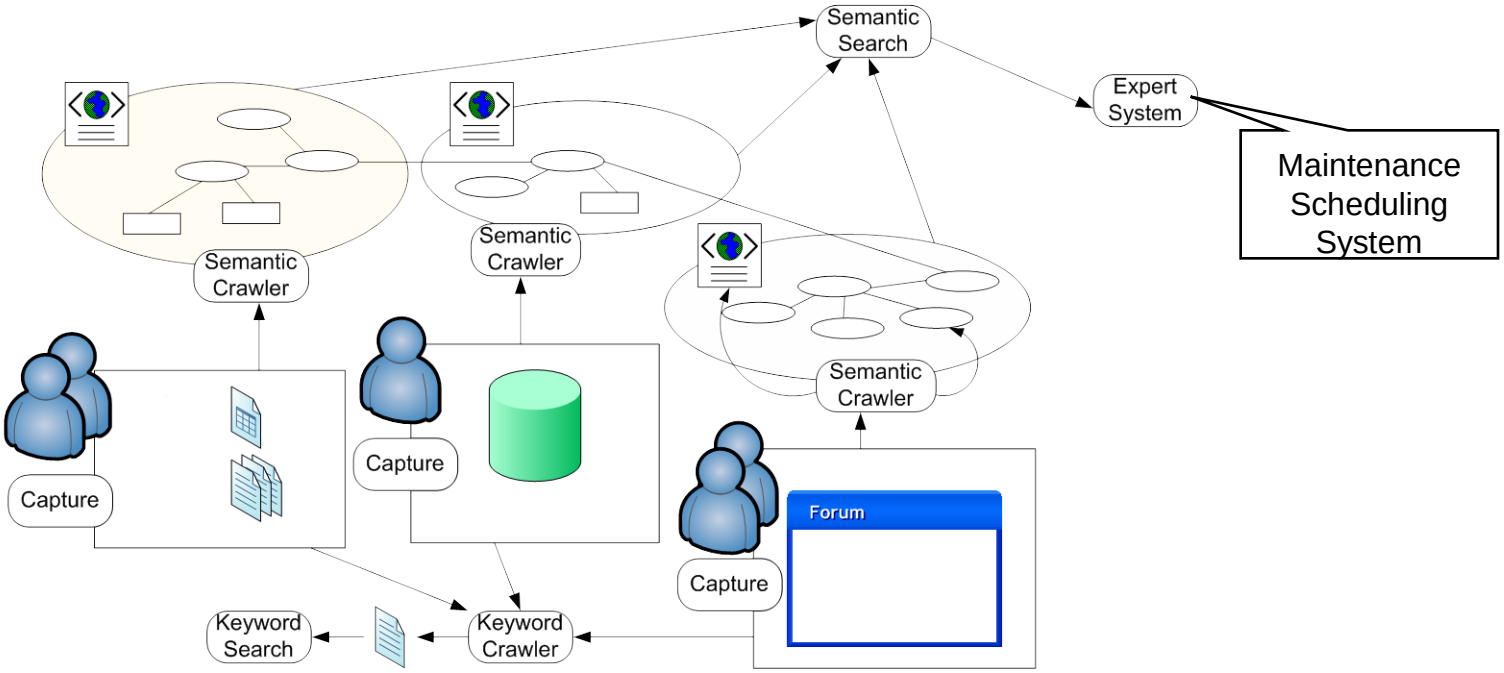
Information System – Extending the System

- New repositories can be added dynamically as the architecture evolves.
- The ontology defined for the new repositories extends the existing system of ontology's.
- An emergence system-of-system domain ontology's is created from the isolated parts.
- Extensions are non invasive; the change to one ontology does not affect another.



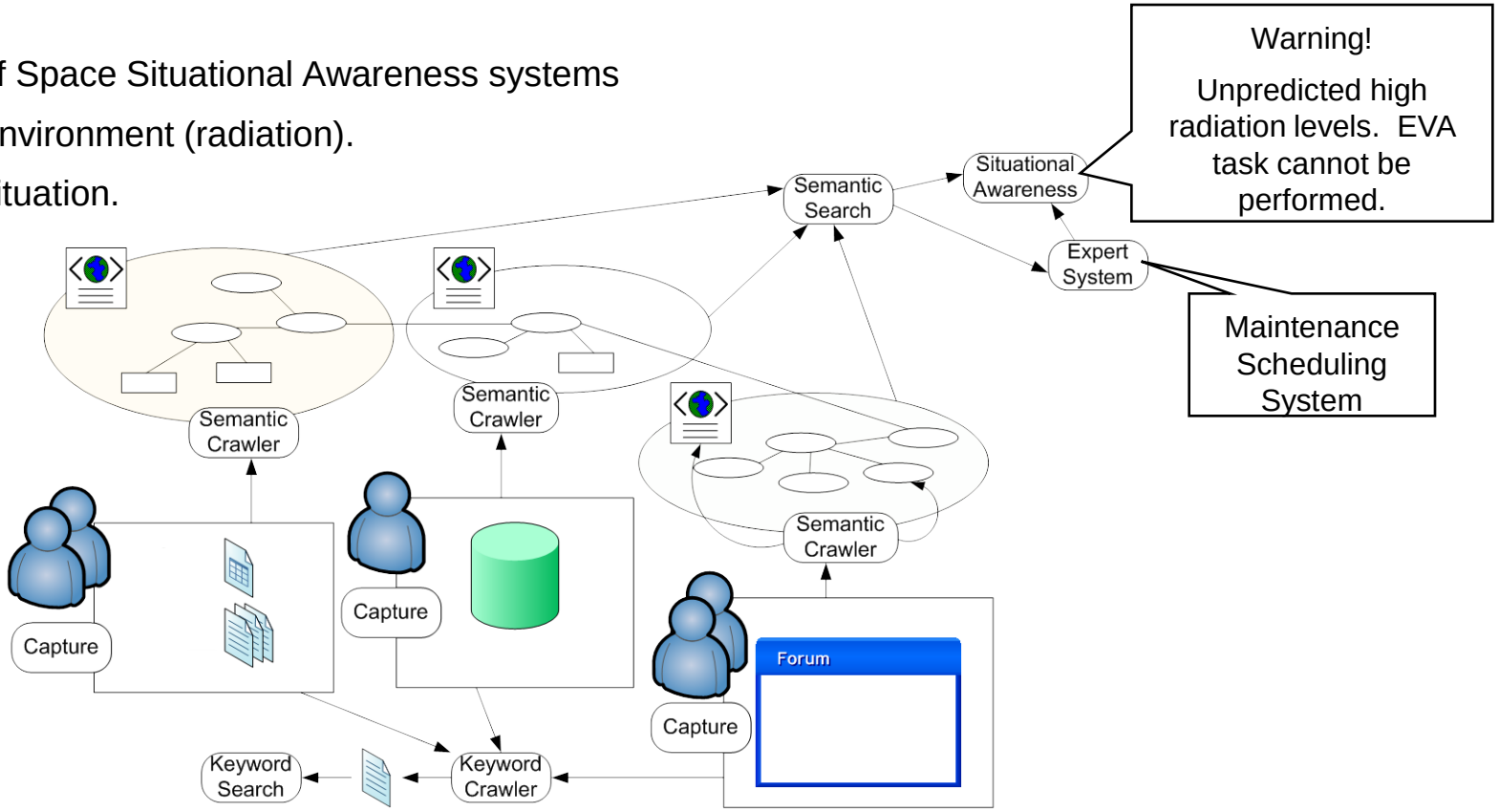
Expert System

- Captures the logic of human experts, automating the extraction of knowledge from information.
- Is enabled through the semantic web.
- Examples of space expert systems
  - Scheduling systems correlating planned tasks, logistic and environment information.



Situational Awareness

- Create a context model, expressing the current situation in regards to a specific perspective and concern.
- Provides an easily human understandable summary and overview of the situation, backed by concrete facts.
- Examples of Space Situational Awareness systems
  - Surface environment (radiation).
  - Logistic situation.



The Problems and the Risks

How can information from disjoint data sources be integrated?

Because if we don't…

- Information and Knowledge may be lost.
- Mission critical information may not reach the people who urgently need it.
- Important scientific and commercial opportunities may not be realizable.
- It becomes difficult to adapt to contingency situations in a timely manner.