10th Central and Eastern European Software Engineering
Conference in Russia - CEE-SECR 2014

October 23 - 25, Moscow

2014
CEE-SEC(R)
Software Engineering
Conference in Russia

# Service Formalism and Architectural Abstractions for Smart Space Applications

## Dmitry G. Korzun

Petrozavodsk State University

# The Problem

- Ubiquitous Computing
  - Smart Environments
  - Multi-agent systems
- Internet of Things (IoT)
  - Ubiquitous connectivity
  - Smart objects
- **Smart space**: A localized IoT-aware service-oriented computing environment with a shared view on resources

SmartRoom System (example):



Dmitry Korzun: Development of Smart Space Applications

24.10.2014
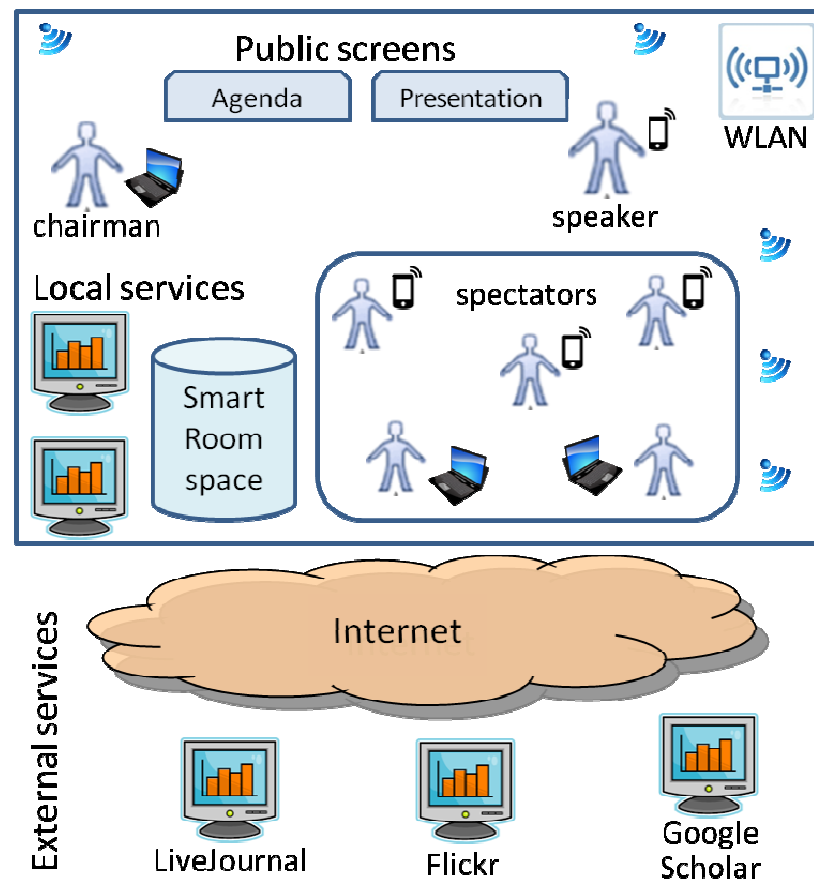
# Smart Spaces

- Multiple data sources:
  - Physical and Information worlds
  - Users generate content
  - Derived information

- Inhabitants: Software agents,
e.g., IoT smart objects

- Hub selectively encompasses the data sources (virtualization)

- Global IoT is divided into spaces (e.g., processors of Big Data)



Dmitry Korzun: Development of Smart Space Applications

24.10.2014
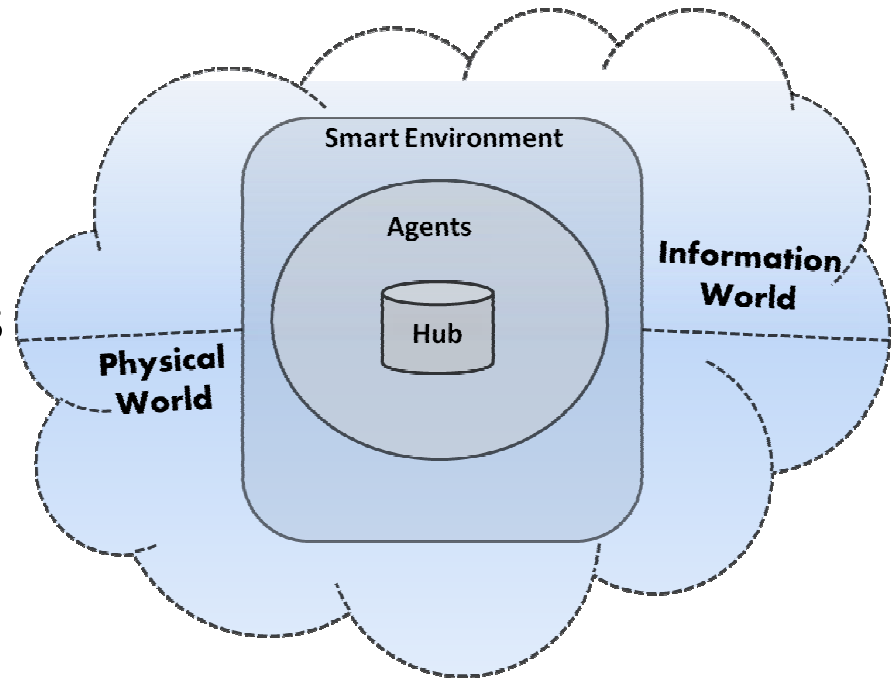
# Enabler Models and Technologies

- Blackboard model: interaction by information sharing
- Semantic Web (knowledge-driven support):
  - RDF model for machine-interpretable data representation
  - OWL ontology for model-driven programming
  - Reasoning over "linked data" (SPARQL)
- Publish/Subscribe model: event-driven programming
- Smart-M3 platform: open source for research prototyping

# Smart Space Application (SSA)

- Distributed system of agents hosted in IoT environment

- Smart properties of SSA:
  1. Understanding the situation where the application is used and by whom
  2. Interpreting the semantics of shared information
  3. Tolerating uncertainty at development and run time



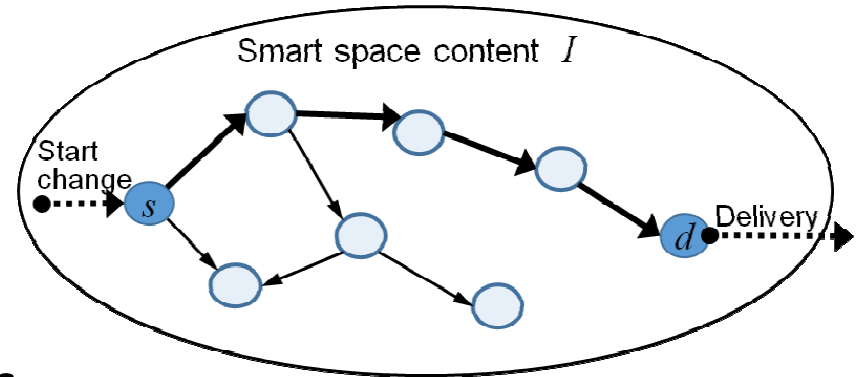Dmitry Korzun: Development of Smart Space Applications          24.10.2014
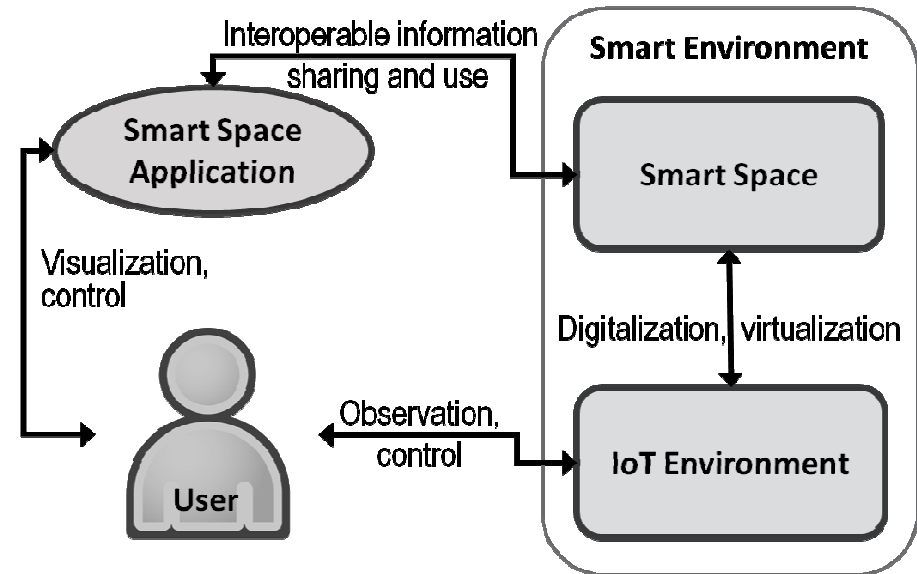
# SSA Services

- SSA acquires knowledge about the environment and its users to provide them with **services** using the best-suit resources from all kinds of participants

- Agent is a Knowledge Processor (KP) over shared content *I*

- Service development: in terms of scenarios with knowledge reasoning acts

- Control flow: initiated from the user side and completed at a point where the user perceives the service
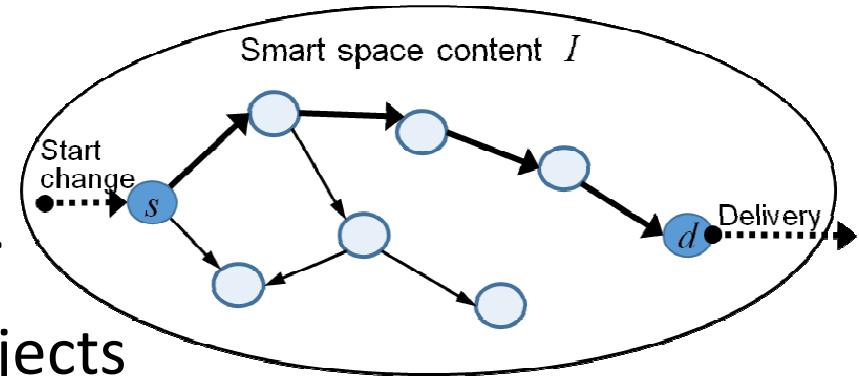
# Service Formalism



- Service:
  - knowledge reasoning over *I*
  - Delivering the result to the users
- Entities of the shared content I are virtualization:
  - Objects of the physical and information worlds
  - Agents and their related information
- P2P-like structure of *I*, including application data (shared), world entities (physical and information), and agents (KPs)

Dmitry Korzun: Development of Smart Space Applications                    24.10.2014

# P2P model



Smart space content $I$

Start change

Delivery

- Any object $i$ in $I$ is treated a peer
- $I$ becomes a set of equal-role objects
- Objects: active entities and subject to information changes
- Interaction: links between objects
  - Ontological (data representation)
  - Meditorial (result of actions)
- Service construction: a flow of information changes, $s \to * d$

Dmitry Korzun: Development of Smart Space Applications          24.10.2014

# Architectural Abstractions

| Type | Description |
|------|-------------|
| P-C | Producer-Consumer pattern. $KP_P$ publishes information into $I$. $KP_C$ queries this information and reacts. |
| Pipe | $KP_0, KP_1, \ldots, KP_n$ form a kind of supply chain (linear) with source $KP_0$ and destination $KP_n$. The P-C abstraction is a particular case for $n = 1$. |
| Tree | Some KPs induce reaction of more than one other KPs. A kind of one-to-many synchronization with epidemic-style dissemination of changes in $I$. |
| Flow | Cyclic supply chains are possible. The KPs are organized in iterative processing flow when the same KP is activated multiple times. |

- Whole app.logic = sum of concurrent activities of KPs

- KP is responsible for links $i \rightarrow j$ of service $s \rightarrow * d$

- Event-driven programming, e.g., persistent semantic query

- Rule-based programming,

- P2P-like routing, e.g., cyclic routing

Dmitry Korzun: Development of Smart Space Applications

24.10.2014

# Conclusion

- Terminology:
  - Smart space and Smart environment
  - Smart space application and services
- Formalization for SSA design
  - Service as a path in the P2P-like network of virtualized objects
  - Architectural abstractions for agents (knowledge processors) that construct and deliver services

dkorzun@cs.karelia.ru