

Smart Spaces

Chapter 2:

Agent interaction models: Blackboard and Publish/Subscribe

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Outline

- § 1. Shared Information Store
- § 2. Publish/Subscribe
- § 3. Software Agents

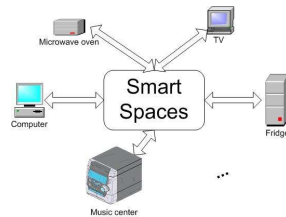
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§1. Shared Information Store

Smart space:

a virtual, service-centric, multi-user, multi-device, dynamic interaction environment that applies **a shared view of resources**



Model of interactions:
Blackboard

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Some Properties

- ▶ Localization and dynamic hub
- ▶ Personalization
- ▶ Adaptability
- ▶ Anticipated construction and proactive delivery of services
 - ▶ Given context (situation): Personal, Environmental
 - ▶ Discover or construct pertinent (most suitable) services for the user

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Operations (Smart-M3)

Operation	Description
Join, Leave	Session to access a smart space
Insert, Update, Remove	Atomic transactions for an element of data. Act of publishing
Query	Requesting information. Various query languages
Subscribe, Unsubscribe	Set up (resp. cancel) a persistent query. Changes are reported to the subscriber

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Space computing

- ▶ Space content: points, tuples, facts $S = (I, \rho)$
 - ▶ Information set = { points }
 - ▶ Rules to deduce new knowledge
- ▶ Shared multi-domain Knowledge Base
- ▶ Corpus-based knowledge representation
- ▶ **Ontology: RDF and OWL representation models (see Ch.3 on Semantic Web)**

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§2. Publish/Subscribe

A paradigm for large-scale Internet-based systems

1. **Publishers:**
generating and feeding the content
2. **Subscribers:**
specifying content of their interests
3. **Infrastructure:**
matching subscriber interests with published content and delivering matched content to the subscribers

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Key Idea

- ▶ **Subscribers**
 - ▶ register their interest in a topic
 - ▶ then asynchronously receive events matching their interest
 - ▶ regardless of the event publisher
- ▶ **They are**
 - ▶ not directly targeted by the publisher,
 - ▶ indirectly addressed through the content

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Properties

- ▶ Asynchronous communications
- ▶ Many-to-many communication paradigm
- ▶ Anonymity: The interacting parties do not need to know each other
- ▶ Decoupling in time: Partners do not need to be up at the same time
- ▶ Decoupling in flow: Sending/Receipt does not block participants
- ▶ Information diffusion

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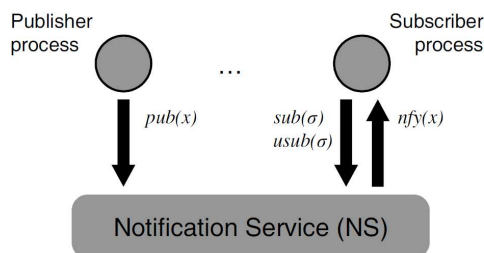
Classification

1. **Topic-based**
 - ▶ Publishers and subscribers are connected together by predefined topics (channels)
 - ▶ Subscription to a topic to receive asynchronous updates
2. **Content-based**
 - ▶ Subscribers query on the content
 - ▶ Content filtering to match subscriber interests with published content
3. **Hybrid of the two**
 - ▶ publishers post messages to a topic
 - ▶ subscribers register content-based subscriptions to one or more topics

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Notification Service



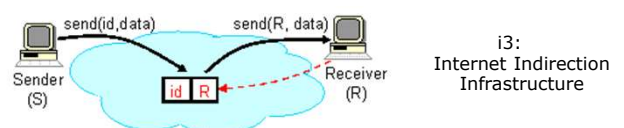
A pub/sub system interaction through notifications

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Case study 1: i3 Model

- ▶ Source (S) sends packets to a logical identifier, id
- ▶ Receiver (R) expresses interest in packets sent to an identifier
- ▶ Delivery is best-effort like in today's Internet, no guarantees about packet delivery

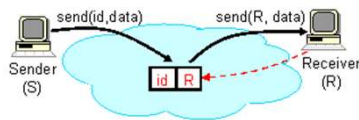


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i3 Logical Rendezvous

- ▶ id represents a logical rendezvous between the sender's packets and the receiver's trigger
- ▶ This indirection decouples the sender from the receiver
- ▶ The senders need neither be aware of the number of receivers nor their location
- ▶ The receivers need not be aware of the number or location of senders



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Case study 2: Pub/Sub Web

- ▶ Frequently updated content
 - ▶ Blogs (Weblogs)
 - ▶ Wikis (collaboratively authored web pages)
 - ▶ News sites
- ▶ Deliver updates to users quickly and efficiently
- ▶ Asynchronous update notification

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Naïve approach

- ▶ Repeated polling at the subscriber side
 - ▶ E.g., Robots
- ▶ Uncoordinated polling suffers from poor performance and scalability
- ▶ Slow receiving updates
 - ▶ Limit posed by the polling period
 - ▶ Polling at faster rates -> high bandwidth load
 - ▶ the same content is polling independently by many subscribers

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Brokers

- ▶ Publishing information through a broker
 - ▶ Middleware to create an infrastructure
 - ▶ In Smart-M3: Semantic Information Broker (SIB)
- ▶ Each broker maintains its subscribers
 - ▶ Subscription table
 - ▶ Filtering
 - ▶ Store and forward function to route messages from publishers to subscribers
- ▶ Infrastructure for routing and information diffusion between brokers
 - ▶ Peer-to-Peer Overlay Networks

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§3. Software Agents

Programming aspects of agents interaction

- ▶ Direct vs. indirect
- ▶ Indirect:
 - ▶ changes in smart spaces content
 - ▶ event-driven and information-driven
- ▶ Direct
 - ▶ due to the hub-property, performance, etc.
 - ▶ access to external data sources
 - ▶ Representation of an origin from physical or informational worlds

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Network connection

- ▶ Agent – Smart Space (Semantic information broker, Shared information store)
- ▶ Session-based: join, operate, leave
- ▶ Instability of network connection (e.g., in mobile networks)
- ▶ Security: e.g., key exchange and data access scope
- ▶ Participation in several smart spaces

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Content Retrieval

- ▶ Search queries
- ▶ Specification of needed data/information/knowledge
- ▶ Reasoning on the smart space side
 - ▶ Search query is a particular case of reasoning
 - ▶ Big Brother approach
 - ▶ Collectively derived knowledge is published for shared use
- ▶ SPARQL (see Ch.3 on Semantic Web)

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Local store

- ▶ To process data, agent must download them from smart space
- ▶ Local decision-making based on
 1. Information from smart space
 2. Local knowledge (non-shared, e.g., private)
- ▶ Sharing the result (partially)
- ▶ Local representation may differ from the shared representation

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Synchronization

- ▶ Event-driven and information-driven programming
 - ▶ do something if a certain event occurs
 - ▶ do something if certain knowledge becomes available
- ▶ Persistent search queries: 1) initiate, 2) operate, 3) terminate
 - ▶ Subscription
 - ▶ Insert and update
 - ▶ Remove?

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Local processing

- ▶ Parallel threads
 - ▶ E.g., main thread and subscription threads
- ▶ Local reasoning
 - ▶ Performance
 - ▶ Relatively small data set to reason over
 - ▶ “Big brothers”

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Thinking on Student Project

- ▶ What devices do you need for hosting the agents?
 - ▶ Computers (laptops, desktops, server machines, ...)
 - ▶ Embedded devices
 - ▶ Personal mobile devices (smartphones, gadgets, ...)
 - ▶ Web services and data sources in the Internet
 - ▶ ...
- ▶ What agents are needed?
- ▶ What services they implement by interacting?

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Часть 2 проекта

Многоагентная архитектура и детальное проектирование

- ▶ Детализация требований в сценариях использования (шаги по получению и обработке данных, алгоритмы обработки и виды информации).
- ▶ Какую информацию надо делать общей для агентов (общее информационное пространство).
- ▶ Анализ интеллектуальности в рамках разработанных сценариев использования.