An Architecture for Distributed Spatial Configuration of Context Aware Applications

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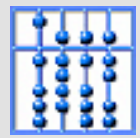
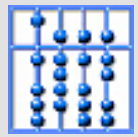


Integrating Client Devices in UbiComp

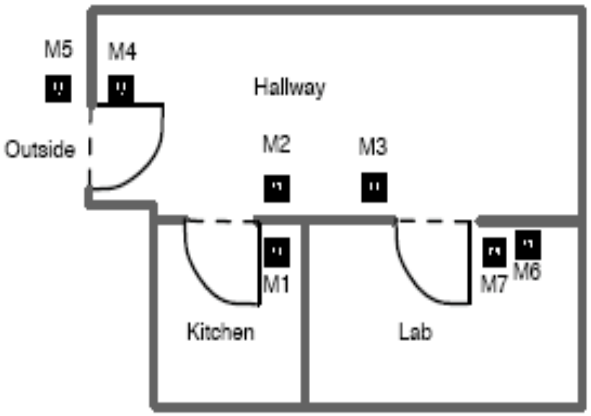
- In Ubiquitous Computing, devices in the environment interact with mobile client devices
- Applications adapt to these devices' capabilities and user's context
- Problem: context aware configuration of users' *mobile client* computers
  - Adapt configuration to current location, activity, time and identity of user
  - Use mobile client's capabilities within the UbiComp infrastructure
  - Allow integration of arbitrary mobile clients *without a priori knowledge*



Overview

- Example Scenario
- Approach: Distributed Configuration
- Software Basis: DWARF
- Automatic Context Aware Configuration
- Implementation Status
- Future Work

Example Scenario



- User walks around smart building, equipment:
  - Camera with optical tracker
  - 3D visual I/O system including HMD and Touchglove
- Mobile and stationary components collaborate in estimating user‘s context, mobile computers need to be configured dynamically
- Applications are composed of application logic in environment and user interface on mobile client
- Applications are chosen and configured based on current user context

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Approach: Distribute Configuration Data

- Configuration data:
  - Data needed for a generic hard- or software device to work correctly in an UbiComp environment
- Drawbacks of central configuration architecture:
  - Whole environment is single complex application
  - Unexpected side effects if configuration is adapted to new applications or users
  - Single point of failure
- Contextually distributed information storage
  - Simplifies partial reconfiguration
  - Allows users to store private configuration data on their mobile clients

Requirements for CA Architecture

- Context aware configuration data
  - Current configuration depends on n-tuple describing current context:
    {location, identity, activity, time, …}
- Transparent access to configuration data
  - Automatic partial or full reconfiguration of client and environment components
  - Transparency allows flexible organization of configuration databases
- Separate context estimation component
  - Facilitates processing of low-level sensor information of both environment and mobile client

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DWARF Overview

- Distributed Wearable Augmented Reality Framework
- CORBA-based middleware dynamically connects *Services* (DWARF components) based on description of their *Needs* and *Abilities*
- No central component, *Service Managers* running on each network node handle connection of services
- Ability descriptions may be enhanced using *Attributes* describing contextual information
- Need description may give *Predicates* for narrowing the search space of matching services
- Abilities may change at runtime depending on how needs are satisfied

DWARF overview (ctd.)

- Once a need and an ability match, DWARF sets up a *connector* that both services use to communicate
- Example: Optical tracker

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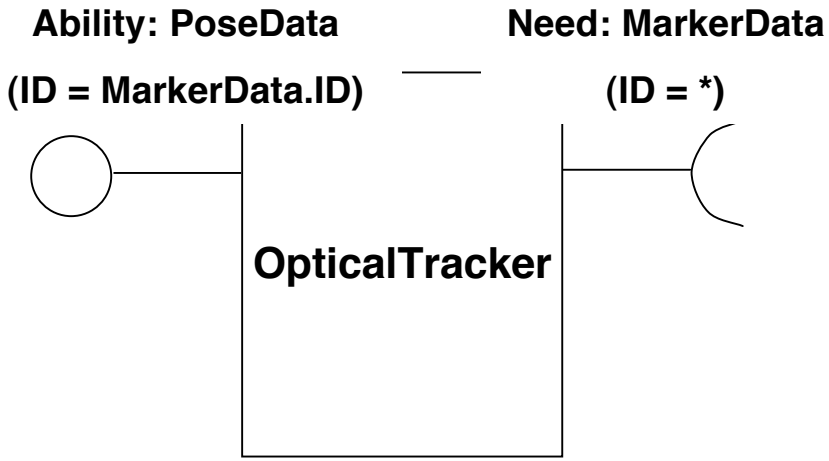

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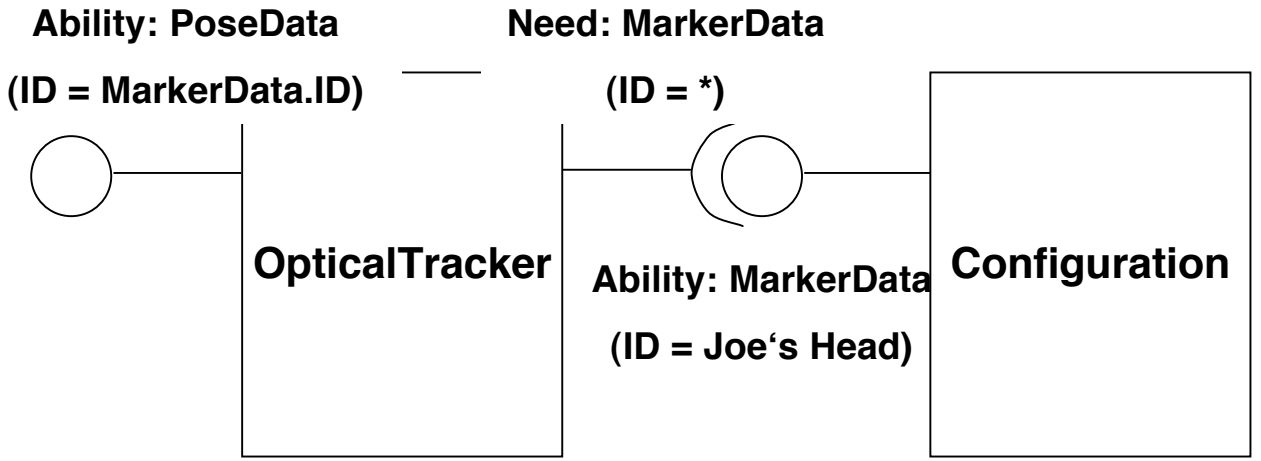

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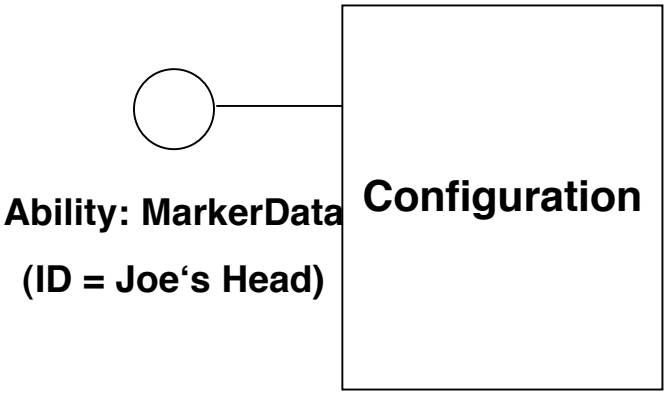

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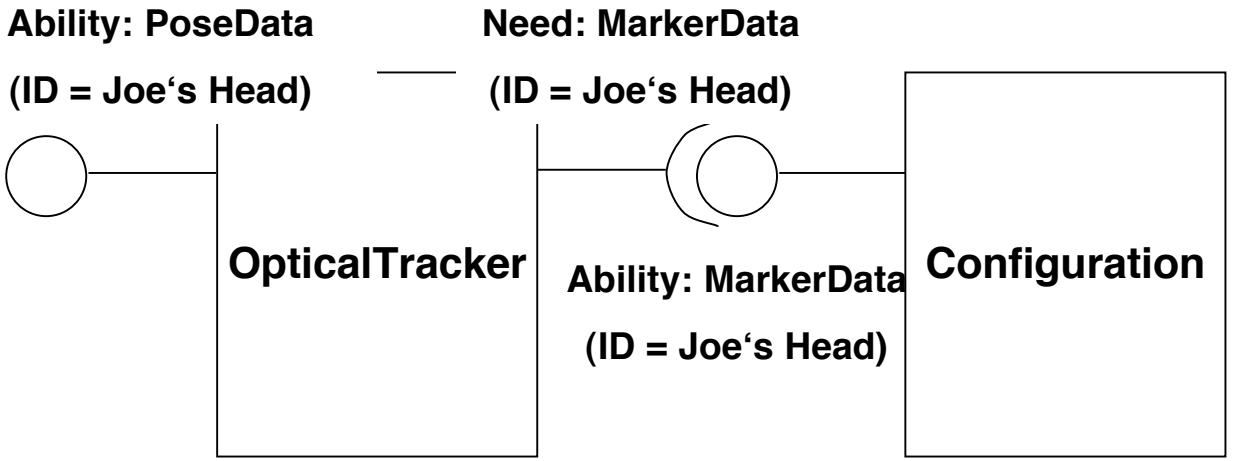

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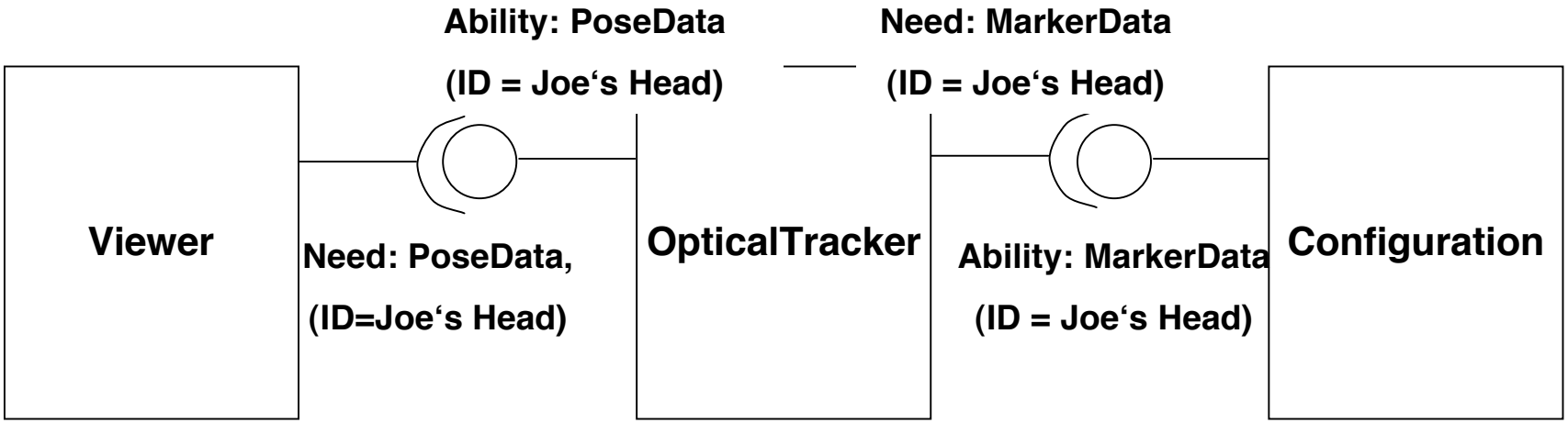

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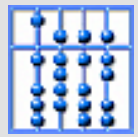
Configuration Architecture: Components

Sensors: Read low-level data influenced by the user's current state; may need to be configured; are both on user's mobile client and in the environment

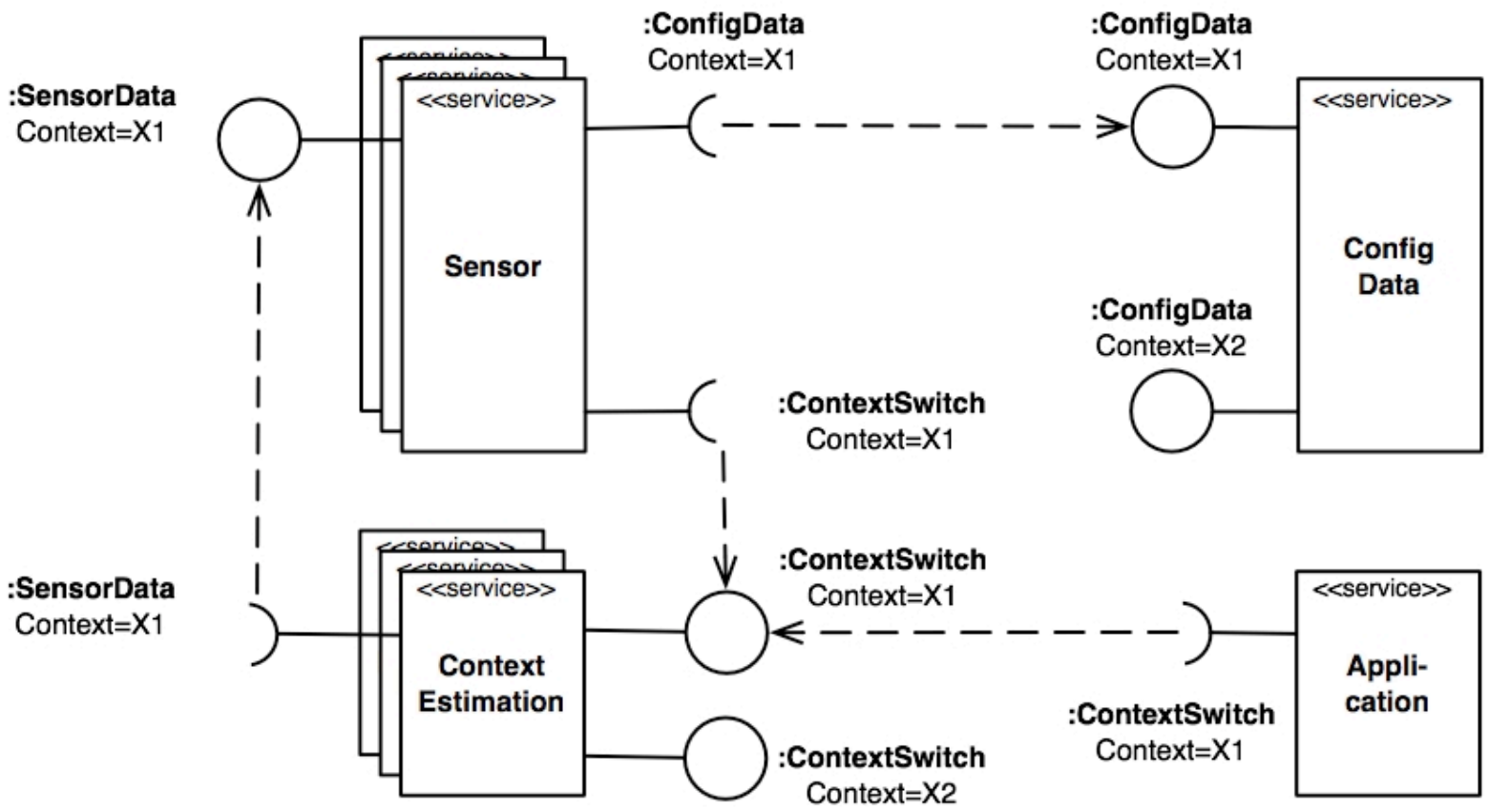
Context Estimation: Read sensor data and estimate high-level contextual information; may need to be configured; are both on user's mobile client and in the environment

Application: Performs certain task for the user; behavior influenced by current context

Config Data: Store configuration data for specific context tuples, reconfigure sensor and context estimation components accordingly



Configuration Architecture: Structure



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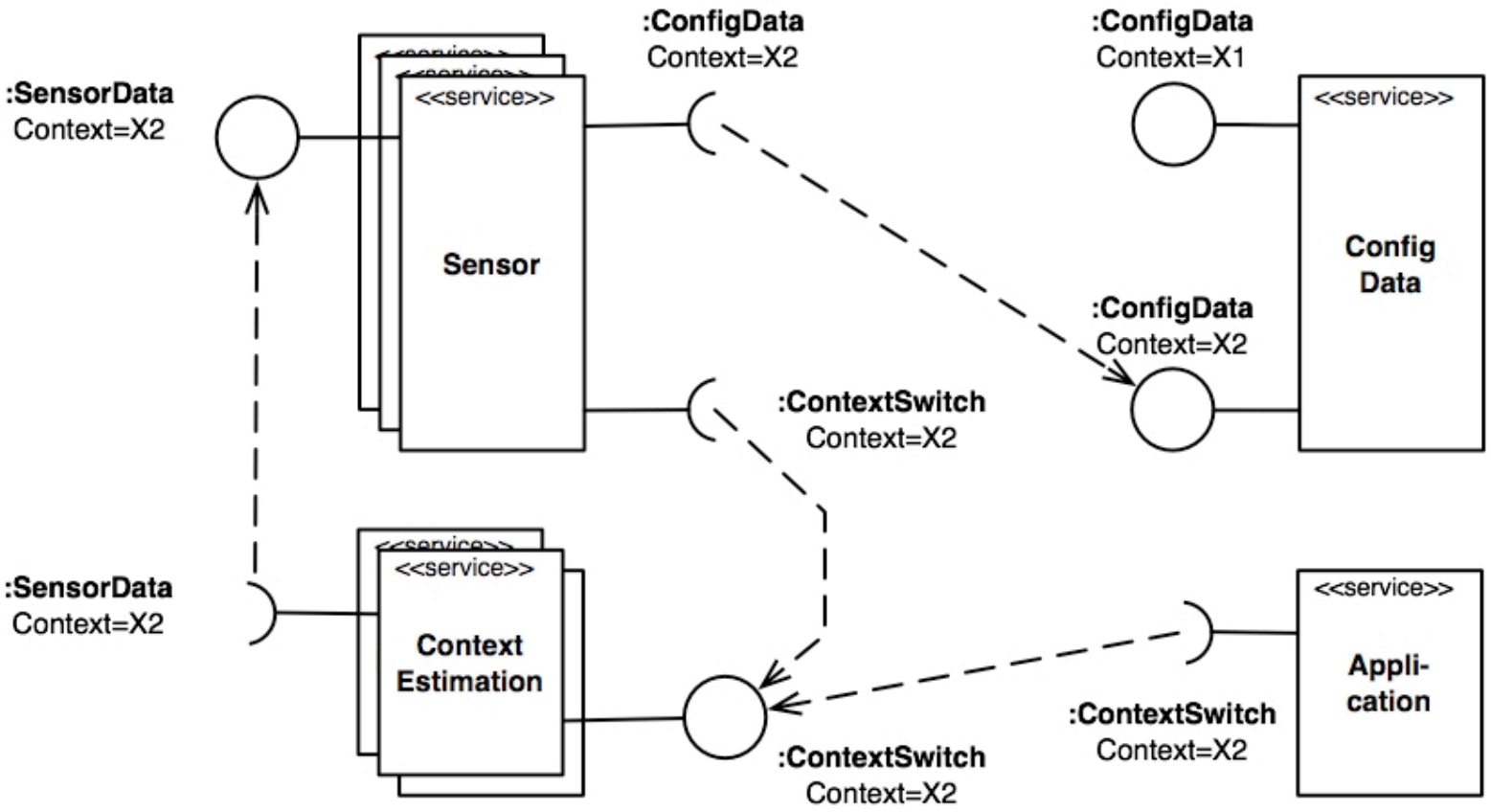


Configuration Architecture: Example

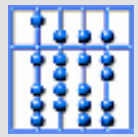
Video Grabber: gets video image and puts it in a shared memory segment

Optical Tracker: Detects fiducial markers in video image and reconstructs camera‘s (i.e. user‘s) position and orientation *(pose)*

Application: Takes user‘s pose and superimposes augmentations over the user‘s view

Context Estimation: Reads camera‘s pose and estimates the room the user is currently in

Config Data: Stores data organized along the different rooms, reconfigures other components accordingly



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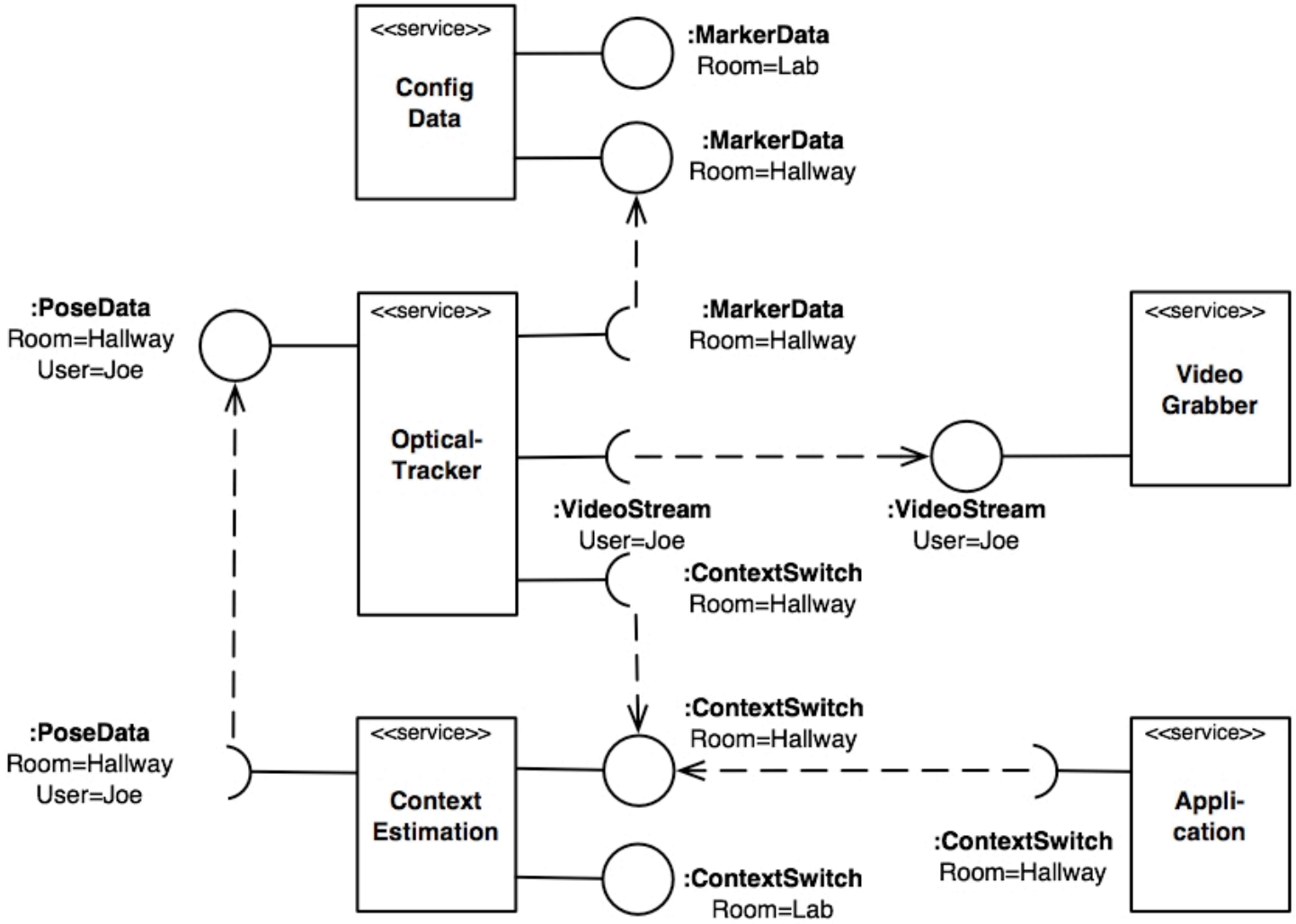

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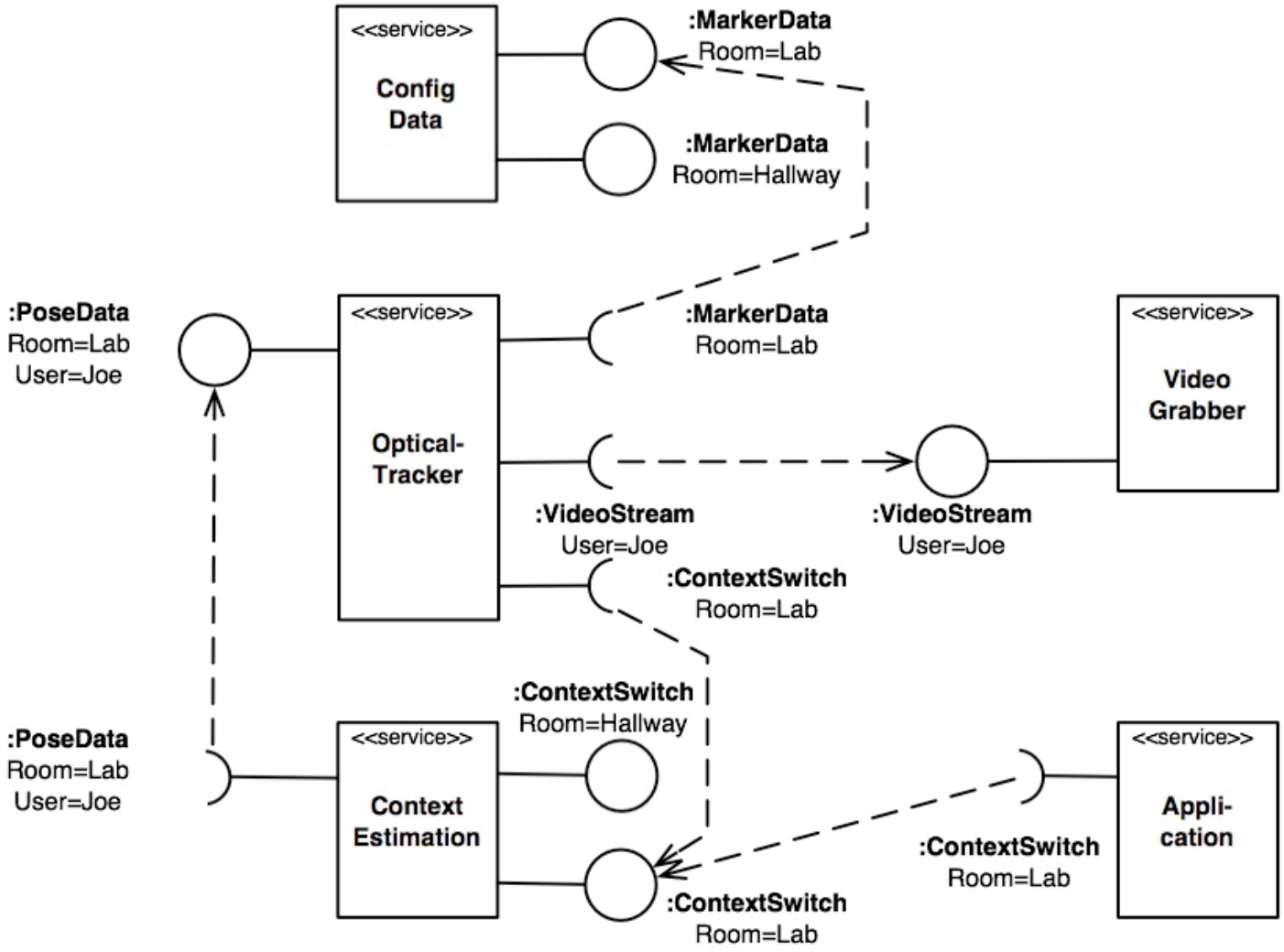

Configuration Example: Flow of Events

1. Building has several *Context Estimation*, *Config Data* and *Application* services running
2. User enters hallway, starts *Video Grabber*, *Application* and *Optical Tracker*
3. *Config Data* service in hallway gets connected to *Optical Tracker* and configures it
4. *Context Estimator* in hallway connects to *Optical Tracker*
5. User leaves hallway and enters lab
6. *Context Estimator* detects changed location context by reading events from *Optical Tracker*
7. *Context Estimator* changes mobile client‘s context attributes
8. *Config Data* service gets exchanged, thereby reconfiguring the *Optical Tracker*
9. *Context Estimator* and *Application* get exchanged as well, allowing user to interact with the lab‘s infrastructure

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Implementation Status

- Demonstration setup with location as only contextual information
- Location structured into 4 different rooms
- Optical tracker uses AR Toolkit
- Application uses speech to tell user information about the current room
- Configuration Data is kept in a MySQL database, a single DWARF ability is offered for every contextual state

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Future Work

- Build larger demonstration setup
  - Implement bootstrapping of contextual state
  - Evaluate scalability of approach
- Refine concept of contextual entities
  - Up to now, we use physical rooms
  - Structure context such that design of new applications becomes more intuitive
  - Learn context boundaries automatically
- Incorporate advanced configuration data access mechanisms
  - Distributed databases
  - Caching and prefetching

Thank You! Any Questions?

More Information:

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A DWARF project – Distributed Wearable Augmented Reality Framework