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Component-based, Context-aware Software Systems

Workshop on Spontaneous Networking

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Outline

- Motivation
- Research Problems
- Thesis
- Example
- Ongoing Work

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Motivation

- Increase of available context information
  - Wireless information devices
  - Integrating increasing number of input and output devices
- Use for applications
  - Explicit, potential
- Use of communication possibilities
  - Remote devices
  - Number of devices

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Context and Context Reasoning

- *Context* is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves.

  [A. Dey and G. Abowd, 1999]

- *Context-reasoning* can be defined as deducing new and relevant information from the various sources of context-data

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Challenges

- Acquisition, processing and provision of context data
- Rapidly changing and uncertain sources

- Reuse
  - Common steps
  - Context information

- Scalability
- Flexibility

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Software Components

- A *component* is a coherent package of software artifacts that
  - can be independently developed and delivered as a unit, and
  - can be composed, unchanged, with other general components to build something larger
- An *interface* is a description of a set of operations related to the external specification of a component. An interface consists of:
  - a set of operations that a component needs to access in its surrounding environment (*required interface*),
  - a set of operations that the surrounding environment can access on the given component (*provided interface*).
- An *operation* is unit of functionality implemented by a component which may map to:
  - a method,
  - a function,
  - a procedure.

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Distribution

- Distributed processing / information sharing
  - Nearby, resulting in a context-aware system
  - Remote
- Simple sensors
- Wireless information devices
  - Online processing
  - Groups of devices
  - Limited resources (processing, storage, networking, power, etc.)
- …
- Servers
  - High level of resources
  - Specialized

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Research Problems

- What are the minimum requirements for a distributed context management system, based on software components?
- How can context reasoning mechanisms be efficiently integrated?
- How can context-aware applications be built from software components?
- How can additional requirements be efficiently integrated?

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Scope

- Ranging from embedded devices, to mainframe computers
  - Context management on user's wireless information device
  - Using remote devices for acquisition of context information and processing tasks (context reasoning)
  - Multi-bearer ad-hoc / P2P networks
- Sensor-based context
  - Not specific to location context
  - Not specific to static contexts (device configuration)
- Context-aware computing view
  - Not specific to semantic web
- Flexible, component-based framework that can integrate additional QAs

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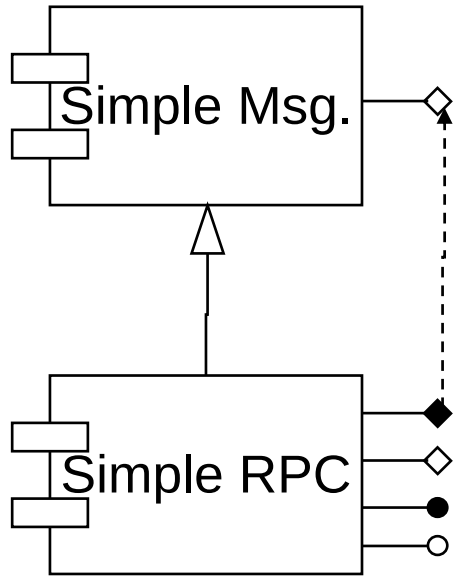
Component Framework

- Functionality
  - Basic sensing
  - Learning + Inference
    - Provision of new context (prediction)
    - Abstraction of higher level of context (interpretation)
  - Store context data
  - Application logic
- Basic communication
- Compile-time / runtime extension with other QAs
  - Access list; restrict communication to specific other components
  - Privacy, security, (network) location

Components

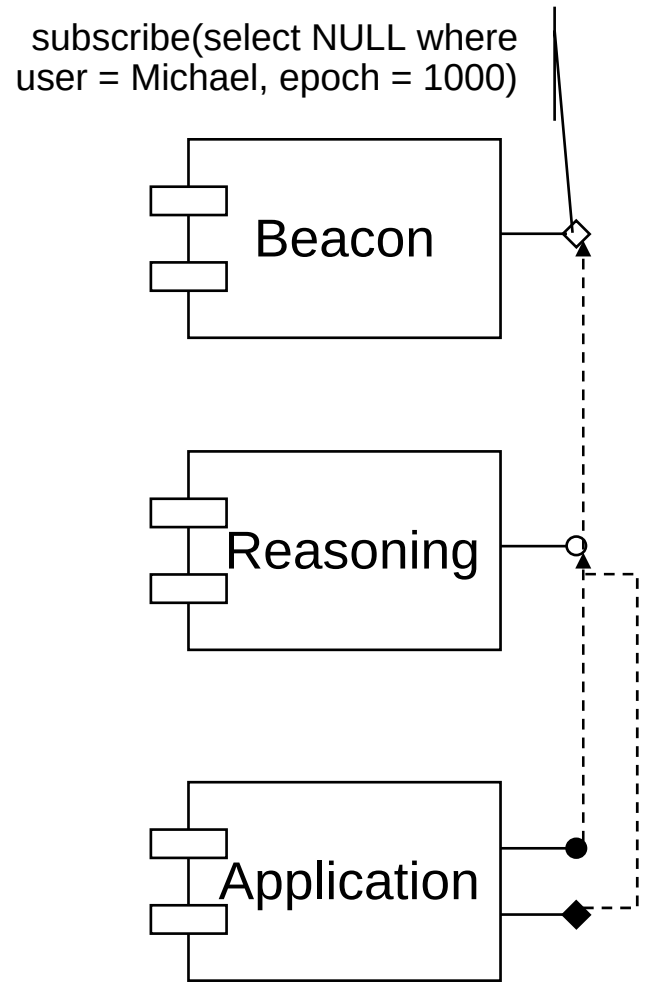
- 1-way communication (Messaging; Publish / Subscribe – Publish; synchronous / asynchronous / isochronous)
- 2-way communication (RPC; synchronous / asynchronous)



- Optimization: combination of components, re-use of common functionalities at runtime

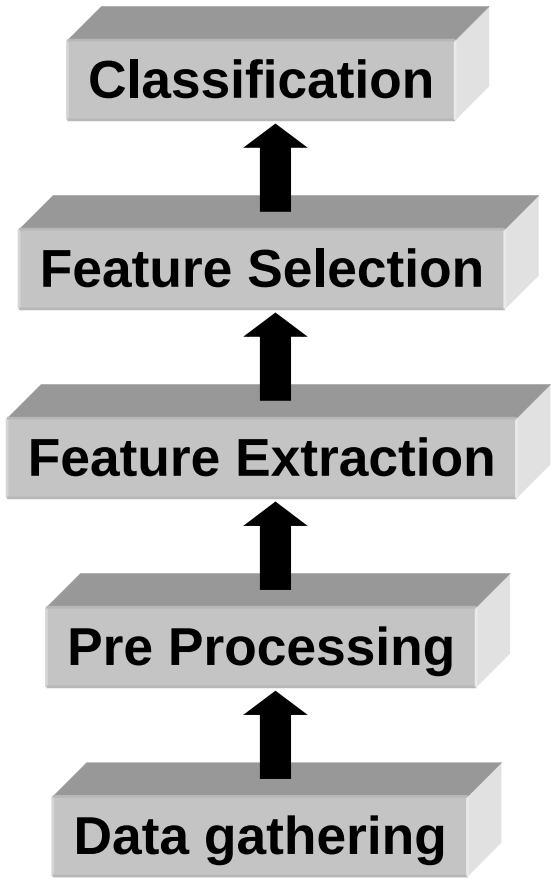
Simple Application

- The stolen / forgotten mobile phone
  - Sensor
    - Simple BT beacon
    - Attached to user
    - Transmit Freq. <= 1 Hz
  - Reasoning
    - Beacon is with user
    - Mobile phone is owned by user
    - Should never be out of reach
      => stolen / forgotten
  - Application logic
    - Sound / display alarm if stolen / forgotten



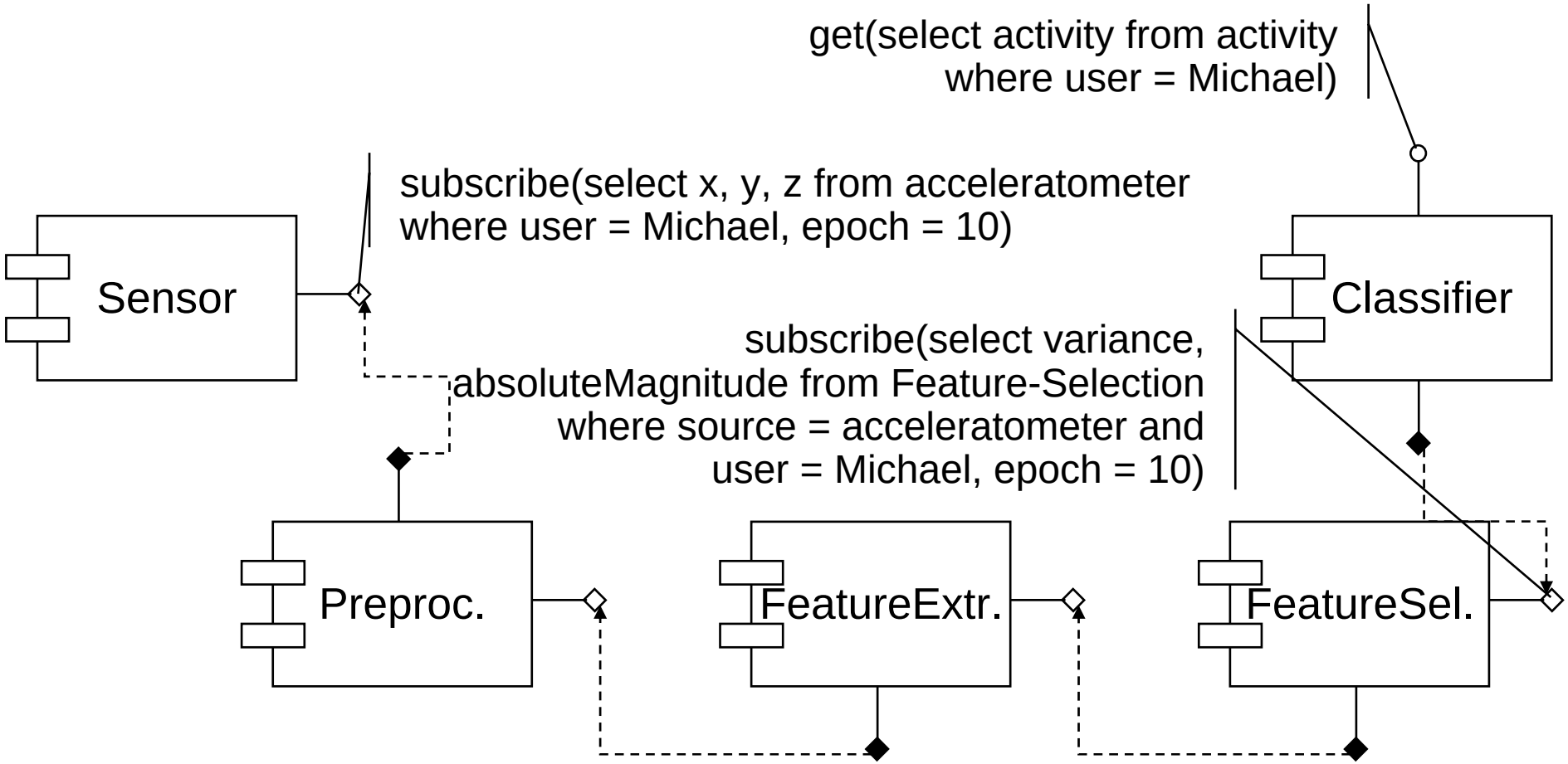
Advanced “Application”

- Inferring User Activity from 3D Acceleratometer
  - Steps



Inferring User Activity from 3D Acceleratometer

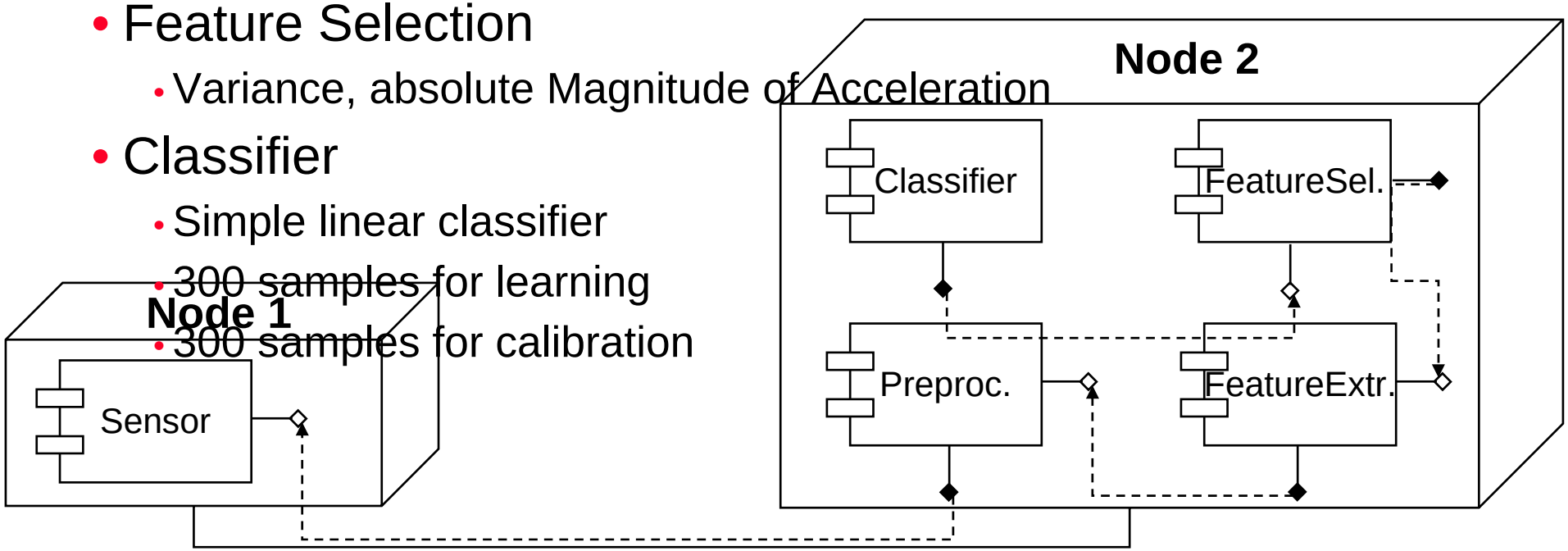
- Components



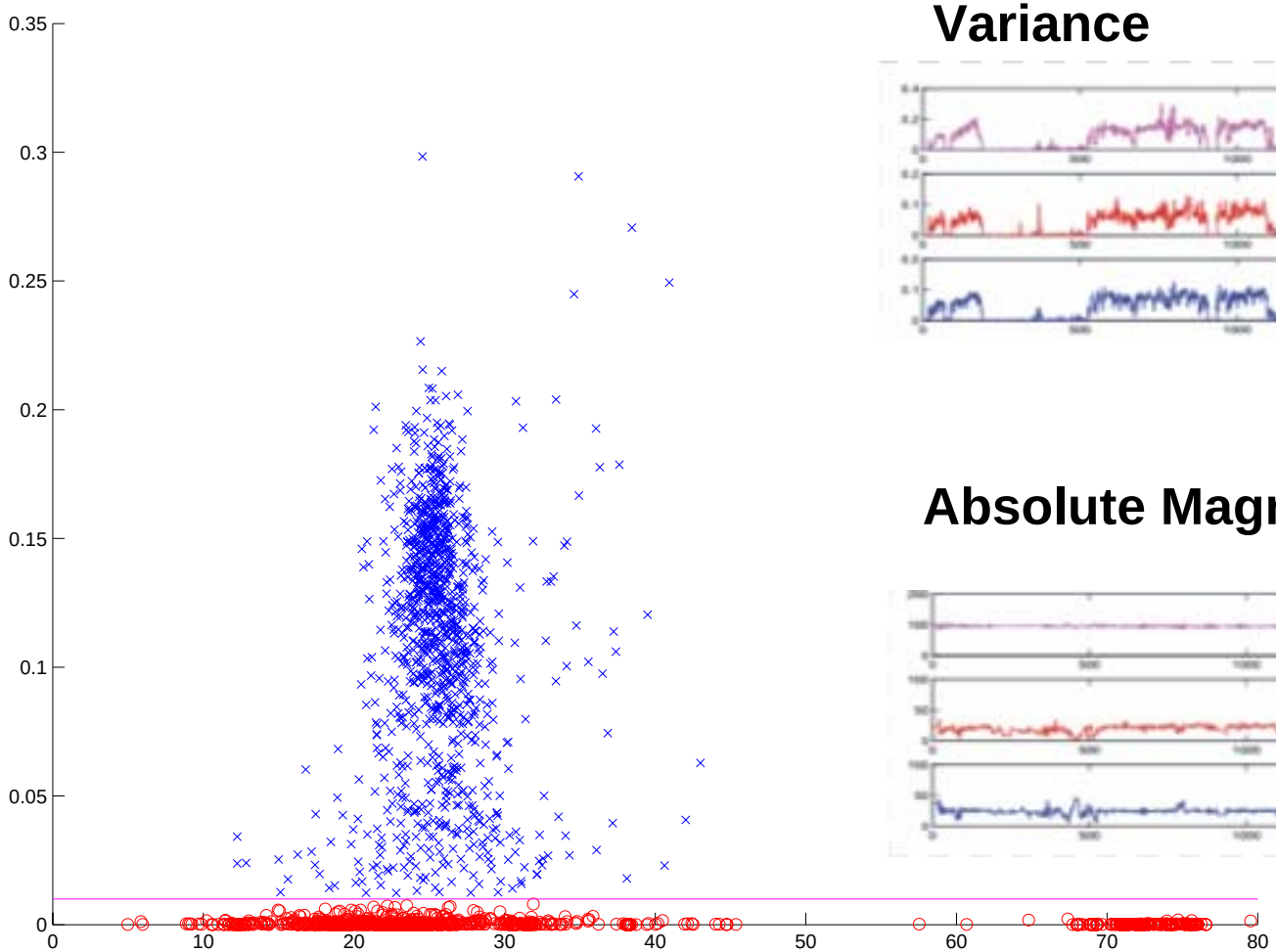
Inferring User Activity from 3D Acceleratometer

- Sensor
  - 220 000 samples (100 Hz)
- Preprocessor
- Feature Extraction
- Feature Selection
  - Variance, absolute Magnitude of Acceleration
- Classifier
  - Simple linear classifier
  - 300 samples for learning
  - 300 samples for calibration

Sensorbox BT Link L2CAP Nokia 6600



Inferring User Activity from 3D Acceleratometer



Variance

Absolute Magnitude

***International Conference on Artificial Intelligence 2005**

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Other work

- Agent-paradigm
  - Distributed preprocessing
  - Integration of policy-based privacy and security
  - Autonomous Intelligent Systems: Agents and Data Mining, 2005
- Evaluation of reasoning mechanisms
  - Software framework for remote data gathering
  - WS / EJB components / WEKA
  - Pervasive Systems and Computing, 2005

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Ongoing Work

- Further integration
  - iMotes (NesC)
  - Series 60 / 80 Mobilephones (Symbian C++)
  - JBoss Application Server
- Communication
  - Ad-hoc (BT) and P2P (IP; 3G/GPRS / LAN)
- Energy saving by remote processing
- Reasoning mechanisms
  - Simple Bayesian networks, SVM

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Questions?