Using Proximity Relations for the Adaptation of Mobile Field Services

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Background: Challenges in Field Services
Mobile maintenance & repair

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Challenges w.r.t. the maintenance of complex devices and appliances:

- **Different editions** of goods ➔ lots of documents
- **Information retrieval** ➔ partly during execution of procedure
- Tracking of workflows ➔ electronic **check lists**
- Smooth **fading between processes** ➔ e.g., switching from maintenance to repair processes
- **Hands-free operation** in special situations ➔ services supporting multi-modality

Scenario:
Nomadic Field Services

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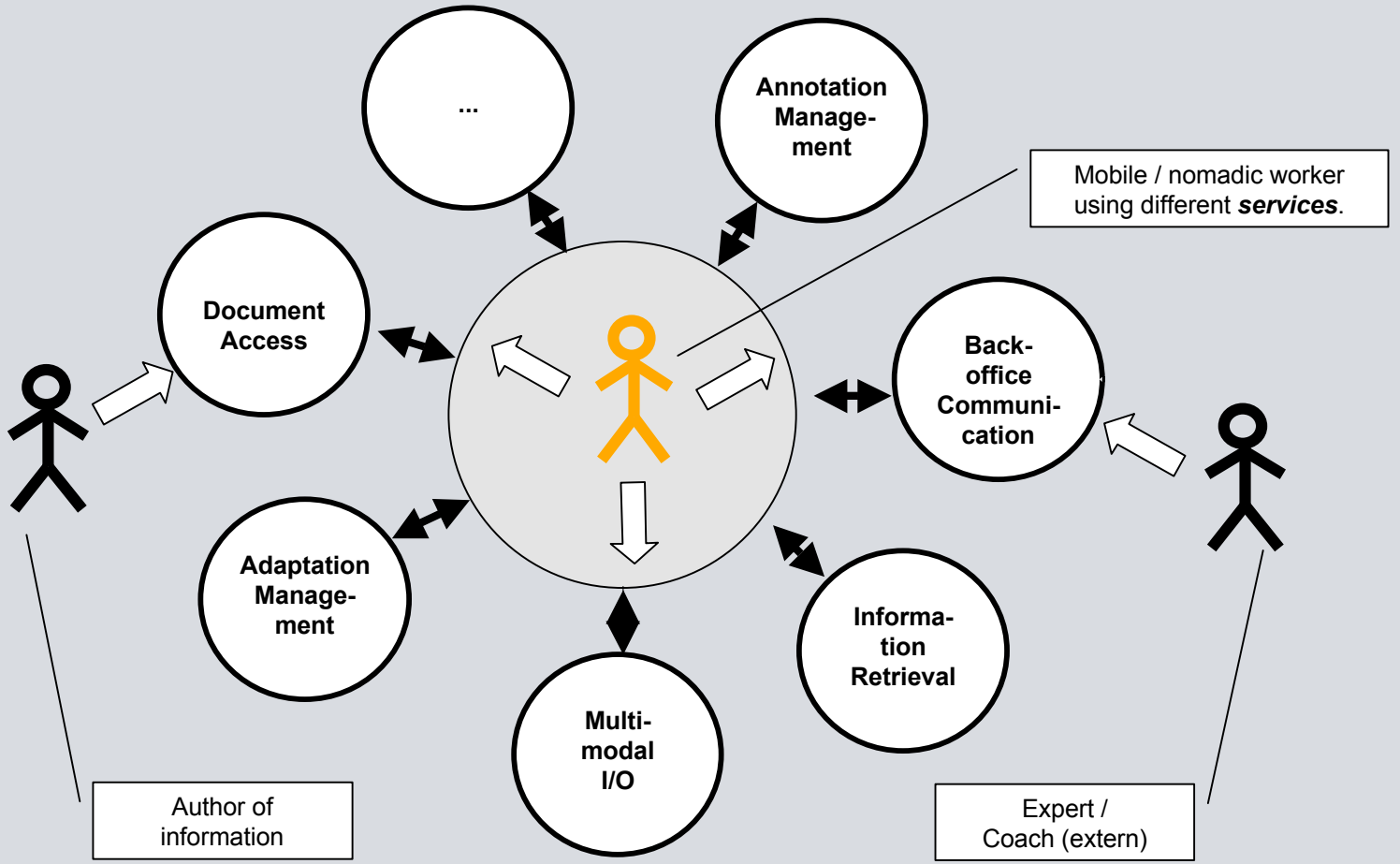

Nomadic Field Services: Solution platform

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- **NoFis#:**
  - **No**madic **Fi**eld **Se**rvices Platform (**#**)
  - Intended to support
    - different **types** (maintenance, repair, assembly, …) of field operations
    - different **sectors** (aeronautics, engineering,…)
  - Wrapping of essential and advanced functions through **services**
    - No strict conceptual alignment to **SOA** (i.e., WSA of W3C)
    - Instead: **REST** for certain services featured (e.g., for speech I/O)
  - Platform can be set up for specific purposes by **composition** and **configuration** of services

Solution:
Mobile Worker Application

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Nomadic Field Services: Context-awareness as platform extension

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- Introducing **context-awareness**:
  - Used to **trigger (inter-)actions**
  - Context **types**:
    - *user* (presence,…)
    - *system* (network / device capabilities)
    - *physical* (**location**,…)
  - Combinations: *spatio-temporal* = location + time
- Targeted impact:
  - **Acceleration** of procedure execution ➔ *reduced effort / time*
  - **Reduction** of error rates ➔ *improved result*
  - …

Scenario: Context-aware Nomadic Field Services

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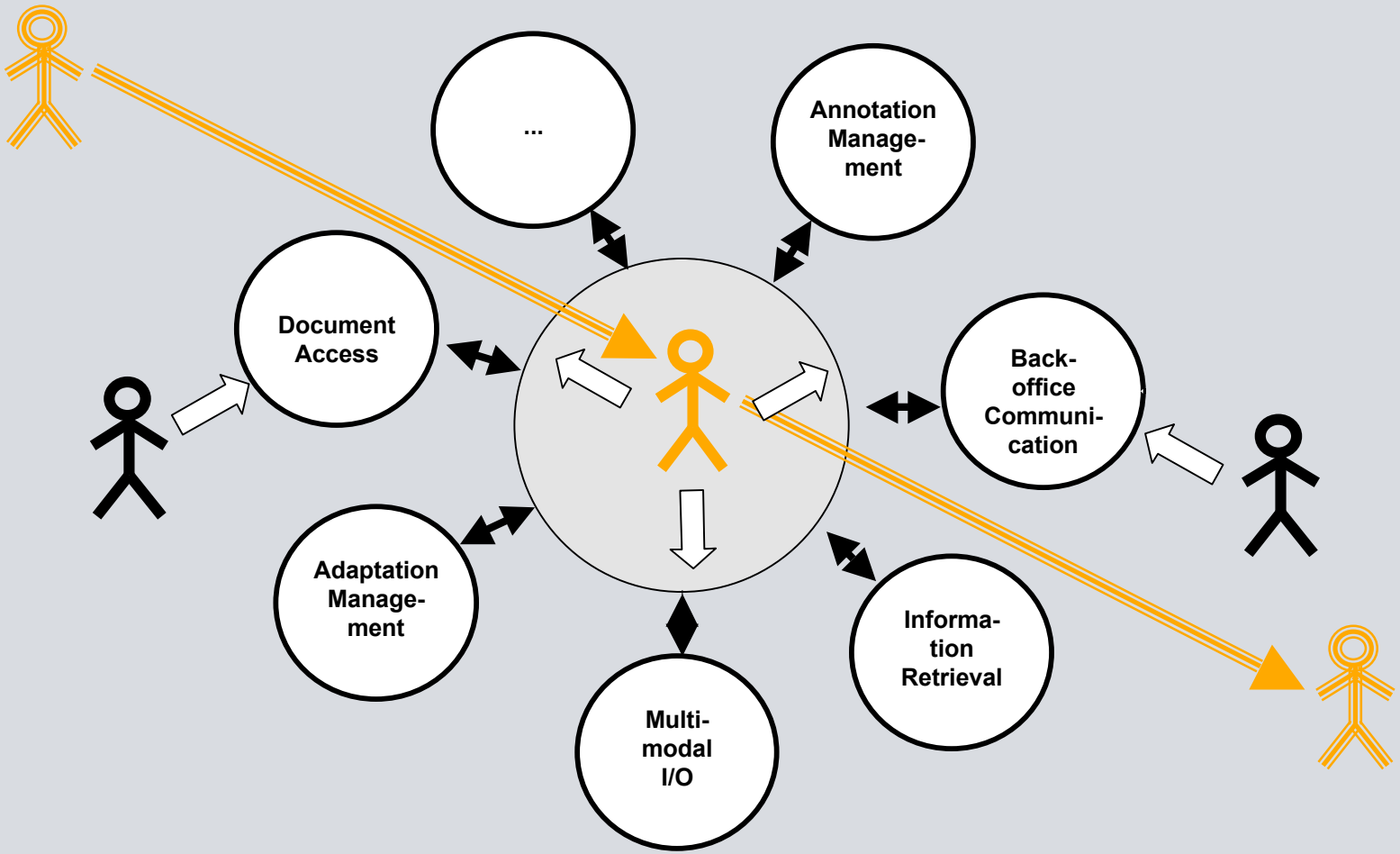

Nomadic Field Services: Context-sensing as pre-requisite

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- Nomadic worker is equipped with a **mobile device**:
  - e.g., PDA or tablet PC
  - could be other *wearable* hardware also
  - tagging: **assets** or **users** are tagged
- **Context**-sensing (tracking) systems:
  - Active Badge System
  - RFID
  - WLAN
  - … (combinations)
- Ability to **integrate** different types of tracking technologies:
  - Lateration / triangulation
  - Scene analysis
  - Proximity
  - **Reason**: the use of certain tracking technology might be impossible (due to interference, shielding, unavailability ….)

Nomadic Field Services: Tracking technologies in the field

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Technologies for user / asset tracking:

	Technique	Accuracy	Tracking
GPS	*Triangulation* (via radio time-of-flight lateration)	10 – 30 m (GPS) 1 – 3 m (Differential GPS)	U
Active Badge	*Proximity* (diffuse infrared cellular)	Room size resolution	U
RFID	*Proximity* (radio cellular)	Depending on the used transponders down to 20 cm	A
Bluetooth	*Proximity* (cellular) and *triangulation* (signal strength)	Room size; could be optimized to approximately 10% of room size	U/A
WLAN	*Proximity* (cellular) and *triangulation* (signal strength)	1 - 5 m	U/A

Scenario: Context-aware Nomadic Field Services

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- **Proximity** deals with the **relative positioning** of objects
- Use case for **proximity**: e.g.,
  - *Configuration of a detailed maintenance procedure of an aircraft (part) is done by analyzing the proximity of the user and the aircraft (part).*

Nomadic Field Services: Proximity for Services Adaptation

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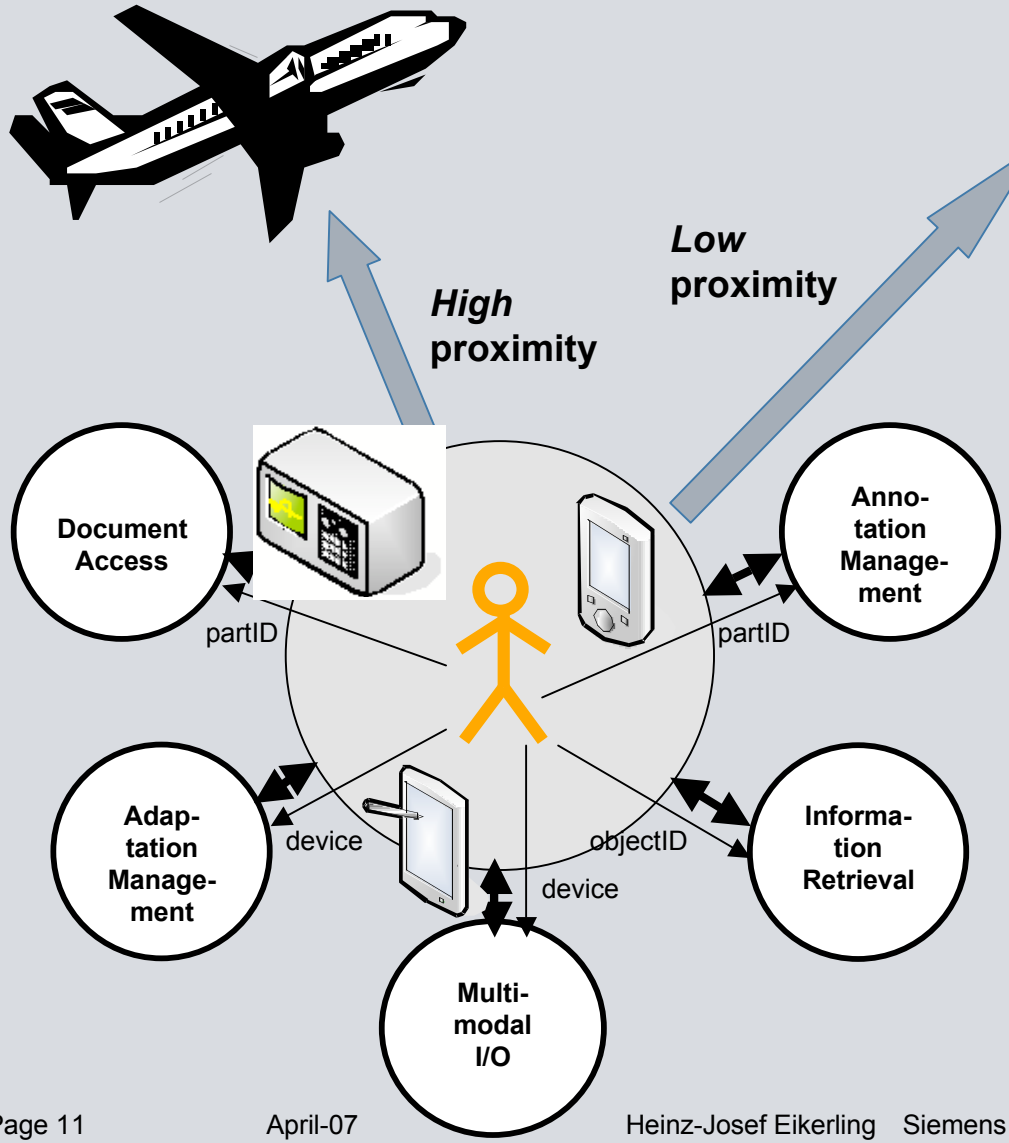

- **Proximity** (*P*): relation between objects (*O*) to be a *reflexive*, *symmetric*, *non-transitive* relation between objects, i.e. $P \subseteq O \times O$
- **Context-Attributes**:
  - Location
  - Time
  - Confidence / fidelity

  ➔ used to establish *P*

Nomadic Field Services:
Rule-based approach to Context-awareness

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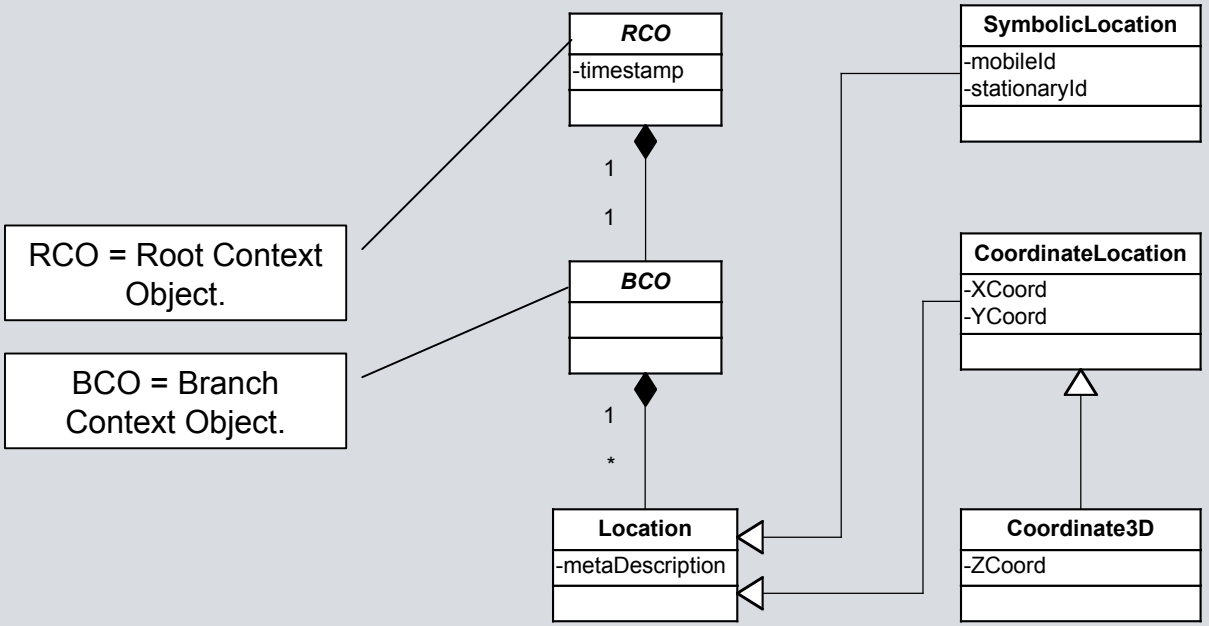
Introducing the **Context Engine**:

- **Analysis** of spatio-temporal relationships through **rule engine**:
  - Context attributes = **facts**
  - Actions / events = triggered by **firing rules**
- **Rule-based transformation** of lower level context information



Nomadic Field Services: Rules in Context Engine

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- Types of **rules**:
  - ***Provider*** rules:
    - describing the **casting** of context data (branch context object) into specific format (*root context object*) before caching
    - provider rules are entered during registration of context provider
  - ***Consumer*** rules: consumers subscribe for context data to be delivered in a specific format (*required context syntax*)
  - ***System*** rules:
    - E.g., policies for storing and removing data from **cache**

Nomadic Field Services: Context Engine

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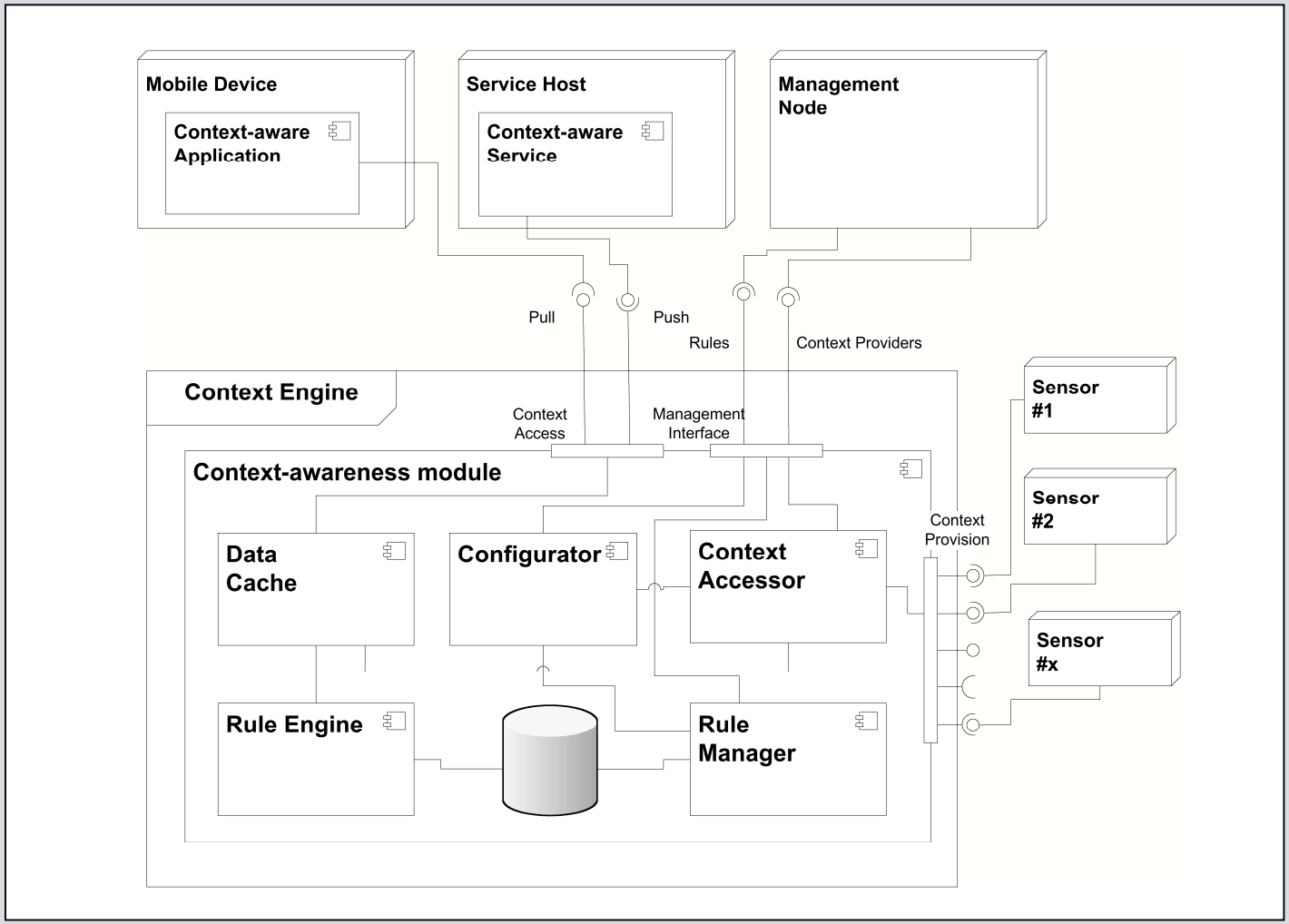

Nomadic Field Services: Integration of Context Engine

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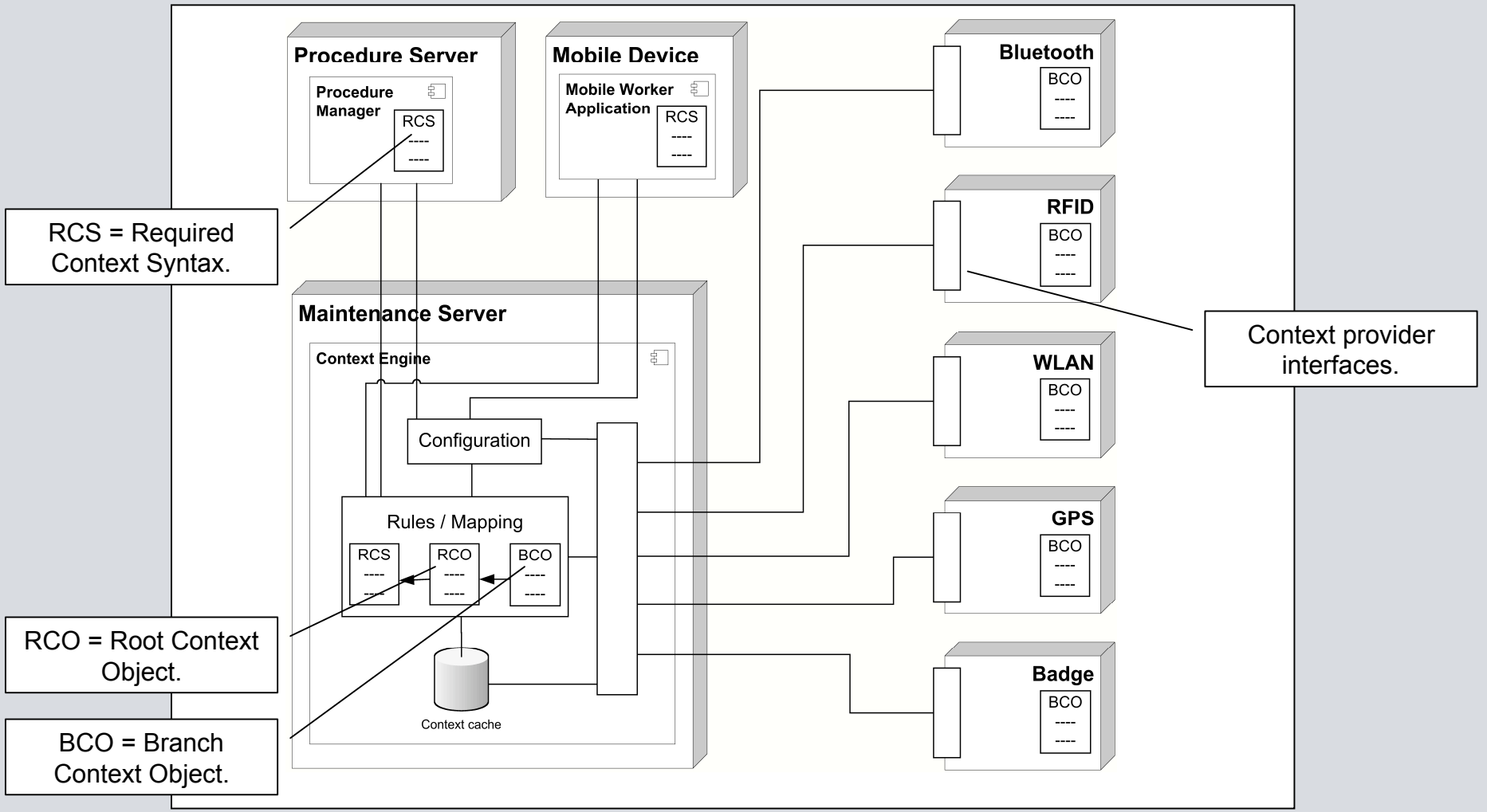

Nomadic Field Services: Results of applying solution

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- Field trials for certain aspects have been conducted
- **Results**:
  - approx. **10%** of the overall time spending for procedure execution can be saved (due context-aware selection of procedure retrieval)
  - no statistics concerning the error-rate exists
  - location context acquisition currently only through explicit **tagging**
  - potentially **scene analysis** techniques will have to be featured

Nomadic Field Services: Conclusions

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NoFiS# as a platform is supposed to be used in other sectors / domain:

- **Sectors**:
  - **Automotive**
  - Large **appliances** / high complexity goods
  - Distribution networks & grids (energy, power,
  - …
  - Aerospace
- **Domains**:
  - Maintenance
  - Repair
  - Production
  - …
  - Manufacturing
- In principal not limited to
  - **B2E** (& B2B): '*Advanced mobile communications paradox*' as major reason for current focus ➔ cost / benefit ratio has to be matched
  - **Nomadic**: *seamless mobility* can be also supported

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Future / Open Research Questions

Questions related to work presented:

- Concept for registering context providers through use of **ontologies**?
- Best way to present proximity relations (extensive configuration, resolution of conflicts, context fusion …)?

Questions to community:

- How to transparently enrich service requests by context information w/o changing service interfaces?
- How can the propagation of context information be controlled w/o deteriorating performance?

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Thank you for your attention!