Resource-Aware Service Architecture for Mobile Services in Wireless Sensor Networks

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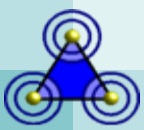
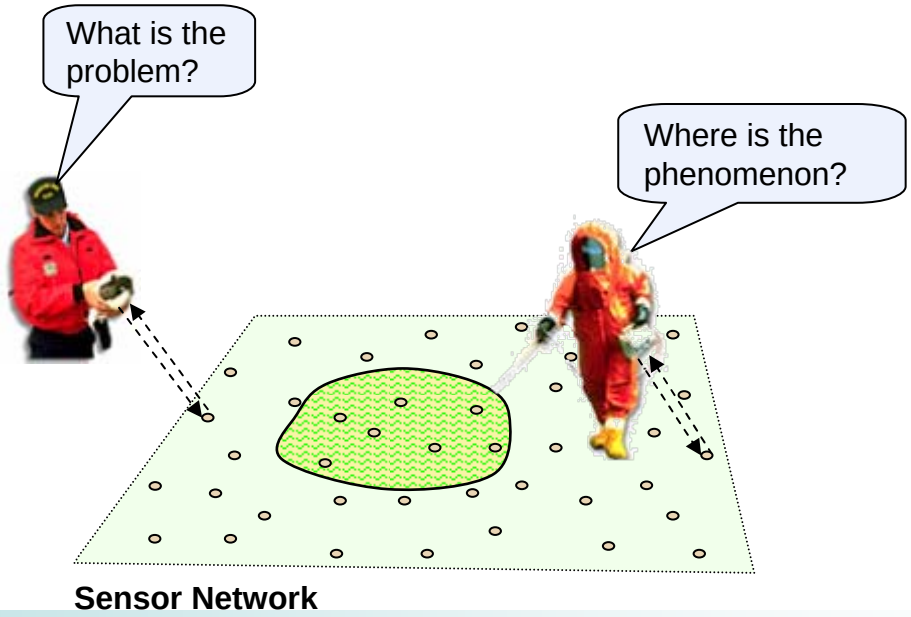


Software for Sensor Networks

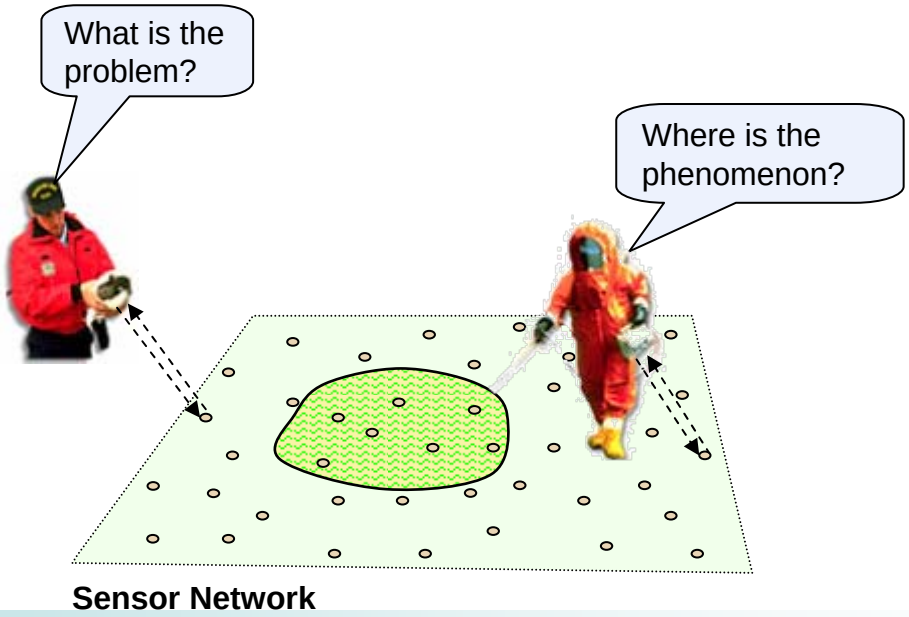
Required Features:

- Adaptable to new requests
- Extracting implicit information (group dimensions)
- Collaboration of several sensor nodes
  - Location dependent services
  - Detection of dynamical phenomenons

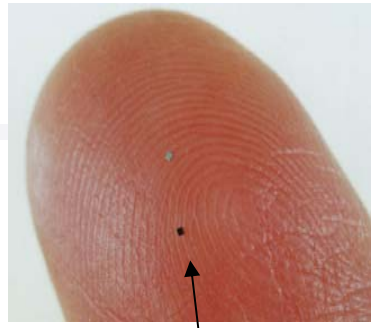


Implementation Requirements

- Applicable for resource-critical devices
- Extremely low memory usage (code and data)
- Adaptable to different memory architectures
- On-the-fly update of software parts
- Reusing existing software
- Low communication effort and low energy consumption



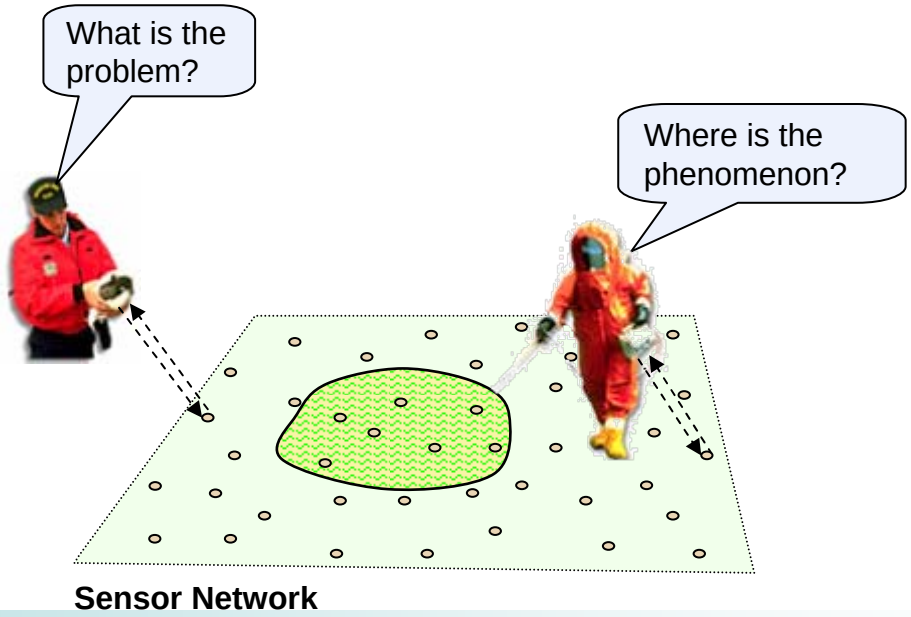
Assumptions



Coming up sensor nodes

Properties in Sensor Networks

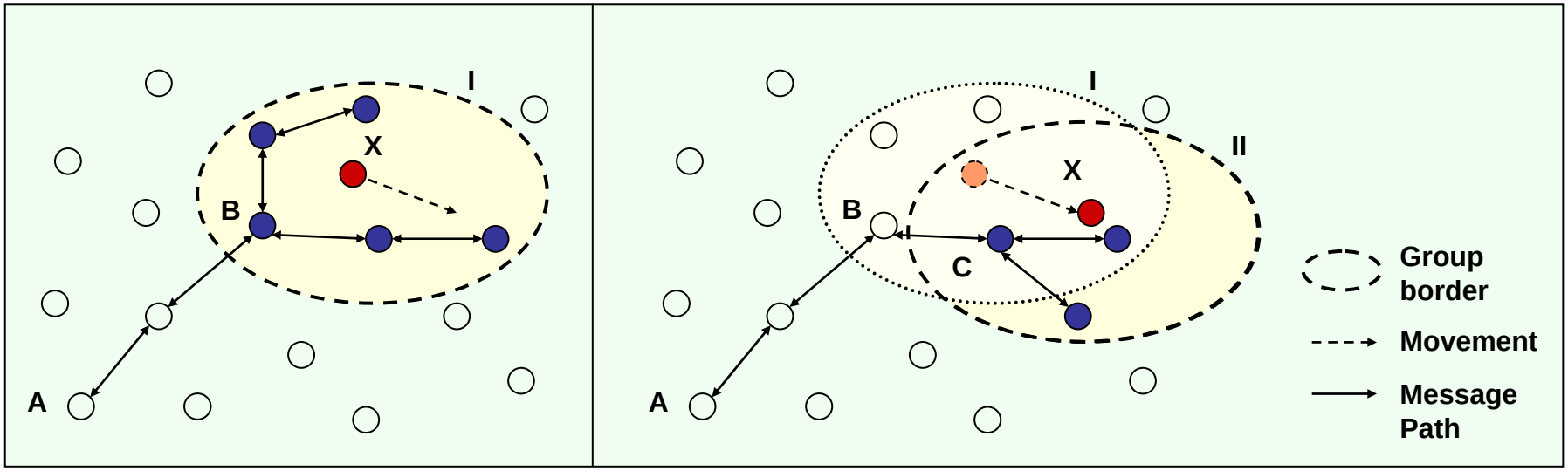
- Cheap homogenous sensor nodes (mass production)
- Small, simple and suitable tasks focussed on measurement and pre-calculation
- Hardware-dependent programming required
- Unsafe communication
- Failure of nodes over time



Types of Collaboration

a) Sensor nodes **build groups** collaboratively based on an object definition

b) **Groups move** with the observed object and may travel around

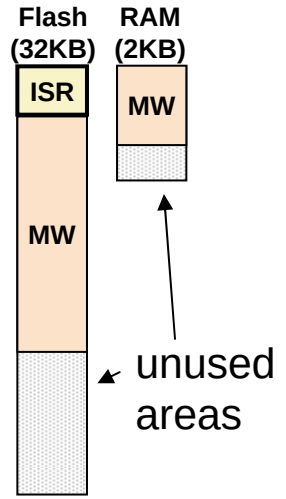


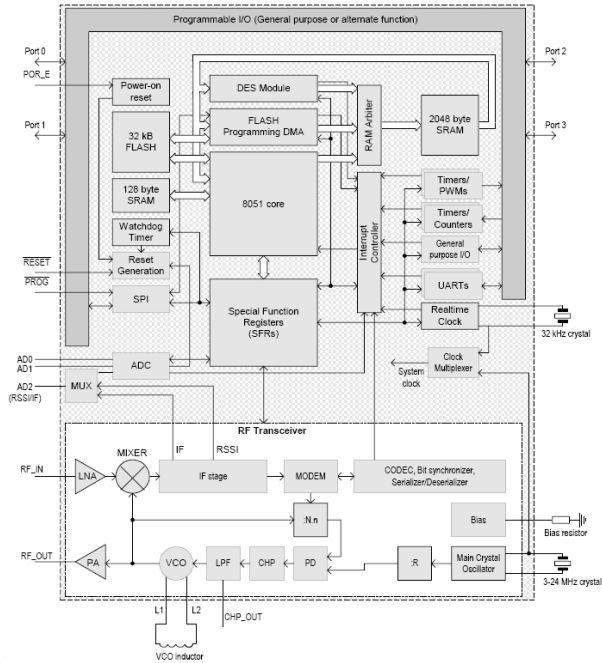
a) Enclose objects (areas)
Where is the temperature > 20°?

b) Observation of mobile objects
What is the average speed of formed object (temperature group)?

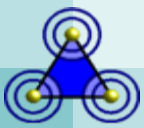
Available Software Architectures

- Software updates mostly stored in RAM
  - not reset-safe
  - only small RAM available (2KB) and usually occupied by operating system
  - data memory needs a lot of energy
- Software is not resource-aware
  - Interfaces between software parts require overhead for adaption and HAL
  - Virtual Code needs Virtual Machine (VM)
- Software (e.g. additional Services) has not full control
  - Often specifics of the microcontroller not suitable configurable (Timers, Interrupts, Ports)
  - Energy-saving mechanisms not applicable
- Mobility support is missing





Service Architecture (RASA)

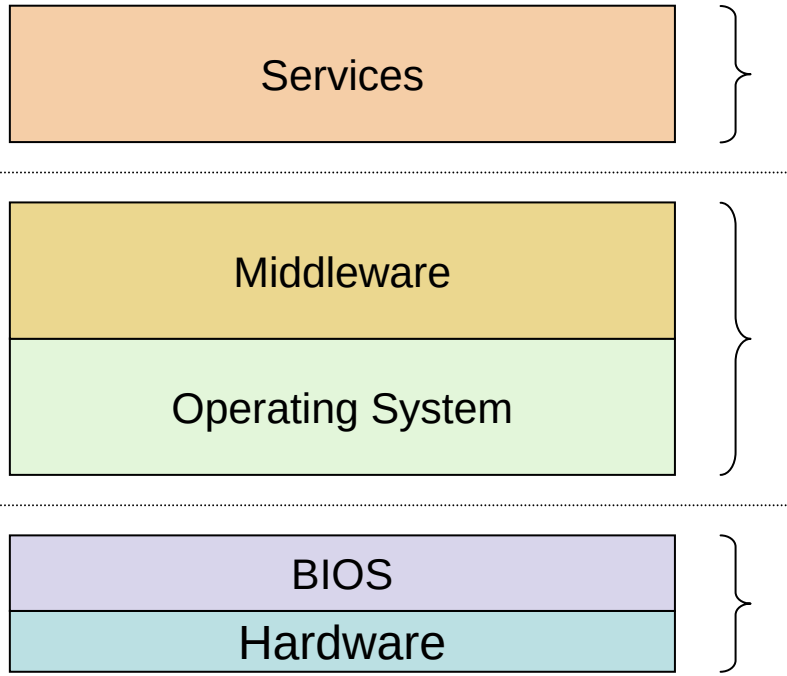


Layered Software Model

- Object and Group Definitions
- Group Management
- Communication Behavior

- Service Management
- Memory Management
- Interrupt Handling

- Startup
- System-Update

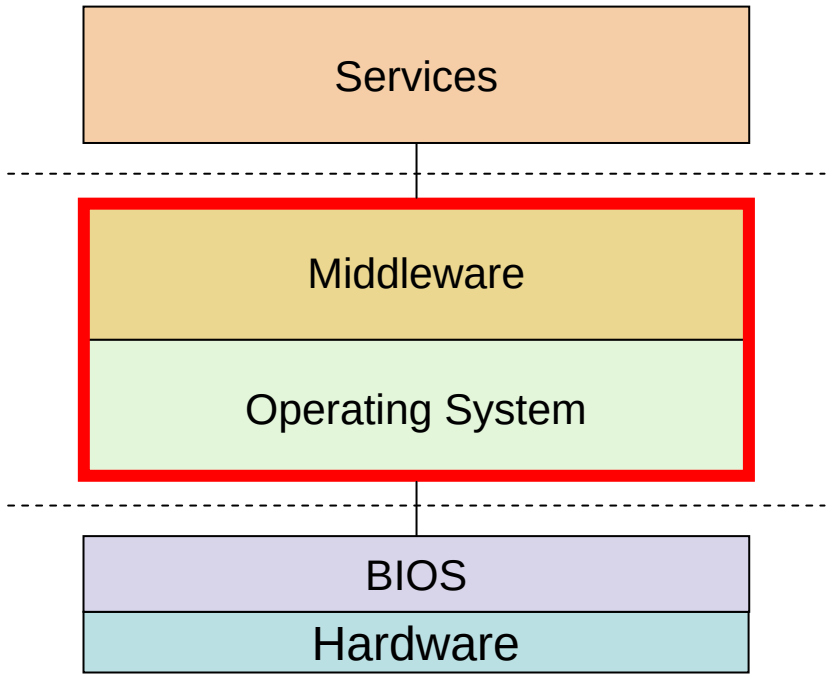


3 Layer Structure

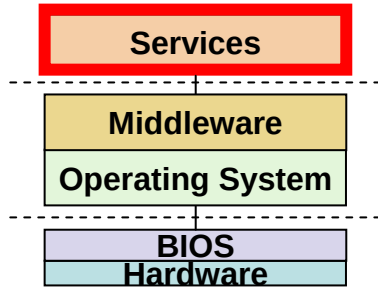
- Minimizes interfaces
- Simplifies development of software
- System layer and service layer are exchangeable at runtime

System Layer

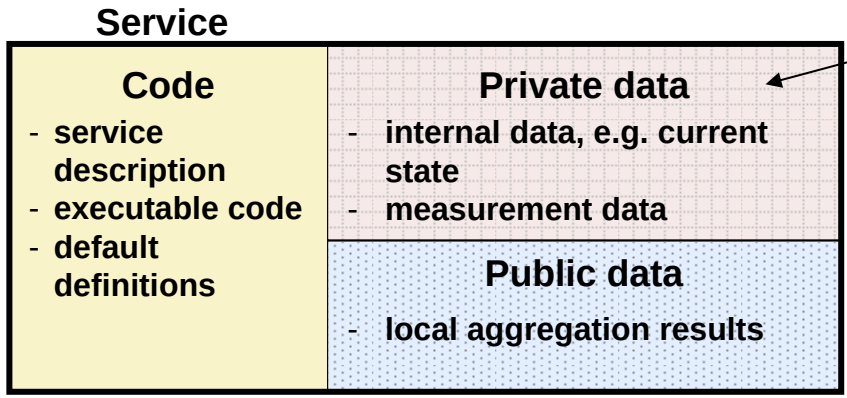
- Contains functionalities of
  - Operating system (transmission, interrupt handling, routing)
  - Lightweighted middleware (service management)
- Not comparable with well-known PC pendants (CORBA)



Service



- Implementation of services as mobile code (native or virtual)
- Mobile native code preferable
  - + very fast and highly flexible
  - + optimizable by compilers
  - + partly platform independent at source code level (ANSI-C)
- No dynamical data at service runtime !
- Three parts:



Only locally available

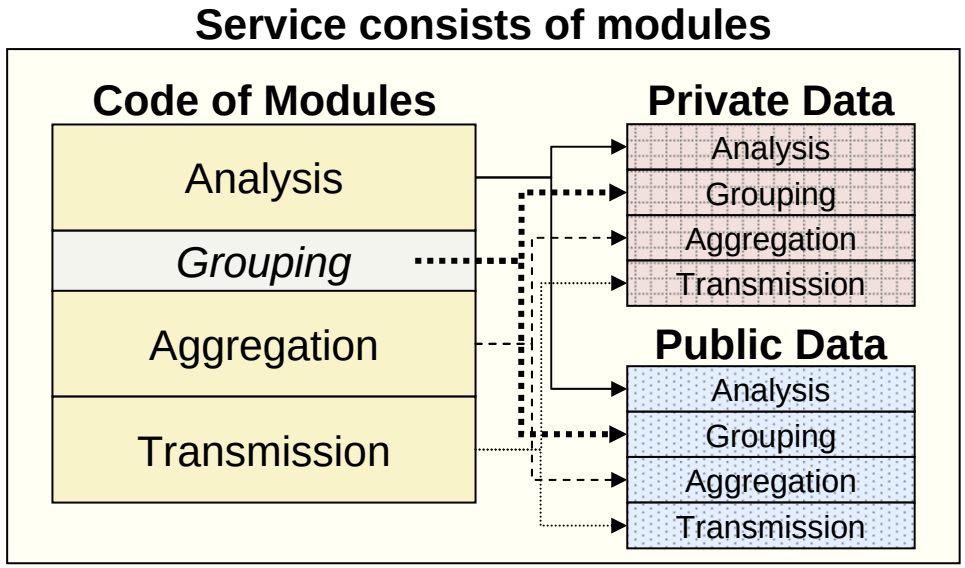
Transmitted to neighbors

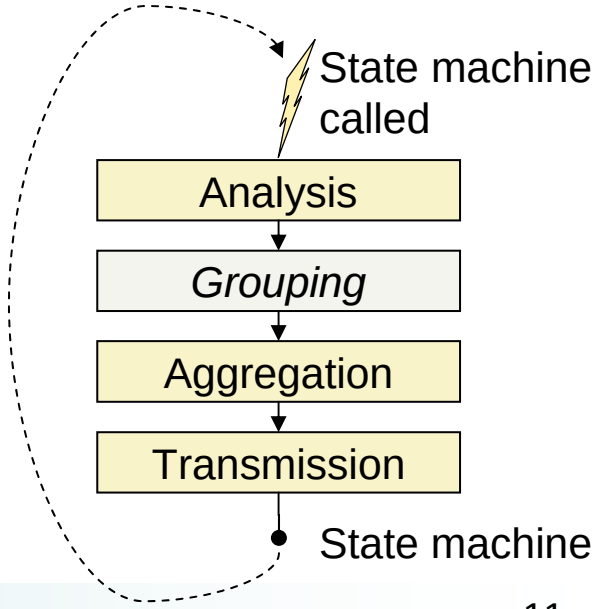
After reception of a message:

- Initialize local instance
- Update own collaboration or calculation results

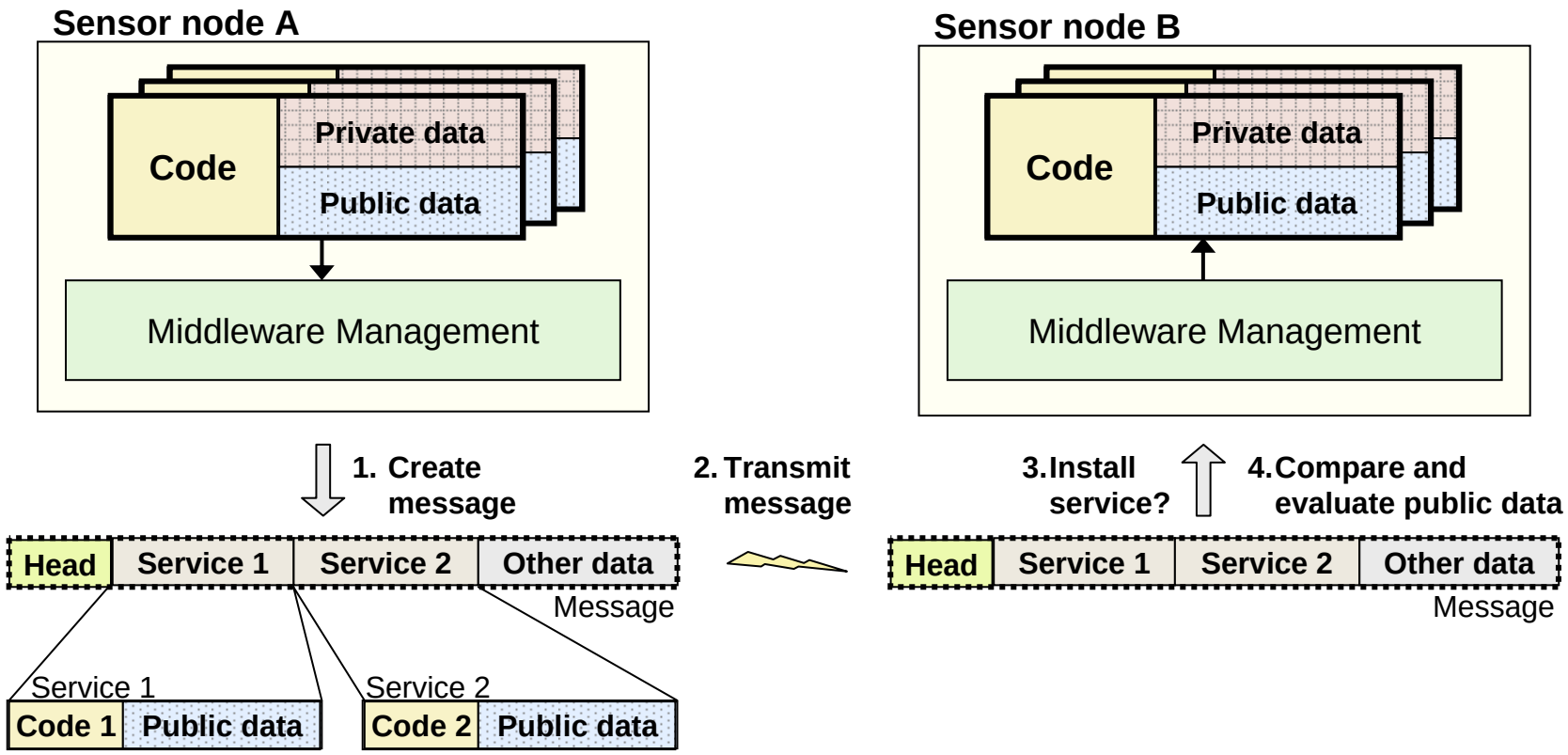
Modules

- Splitting a service into several modules
- This increases
  - interoperability of source code
  - modularity
- Modules are executed
  - in sequence
  - any order, if specified





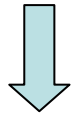
Forwarding Services



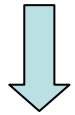
- Service is flashed and installed at runtime once
- **Simply**, code and public data are **copied and transmitted** with each service's message
- Service data may combined in one message by middleware

Robustness

Simply, code and public data are transmitted with each service's message.



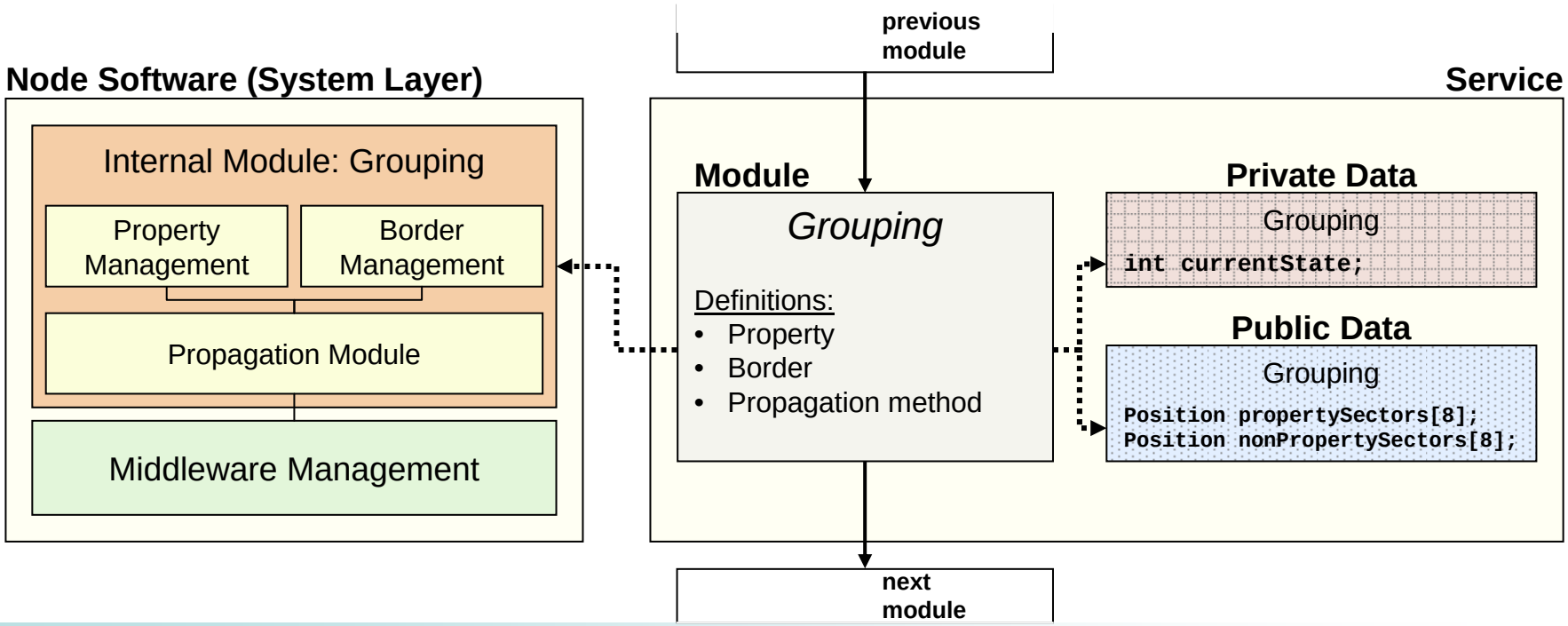
- Prevents a costly protocol overhead normally required for:
  - installing and forwarding a service
  - if a new sensor node enters the network and requires all neighboring services
- Easy collabortation between sensor nodes
- High robustness in sensor network
- Automatically **self-healing effect**, if software is able to work with changing neighbors (e.g. group building)



Services must be very **small in size** (code as well as public data)

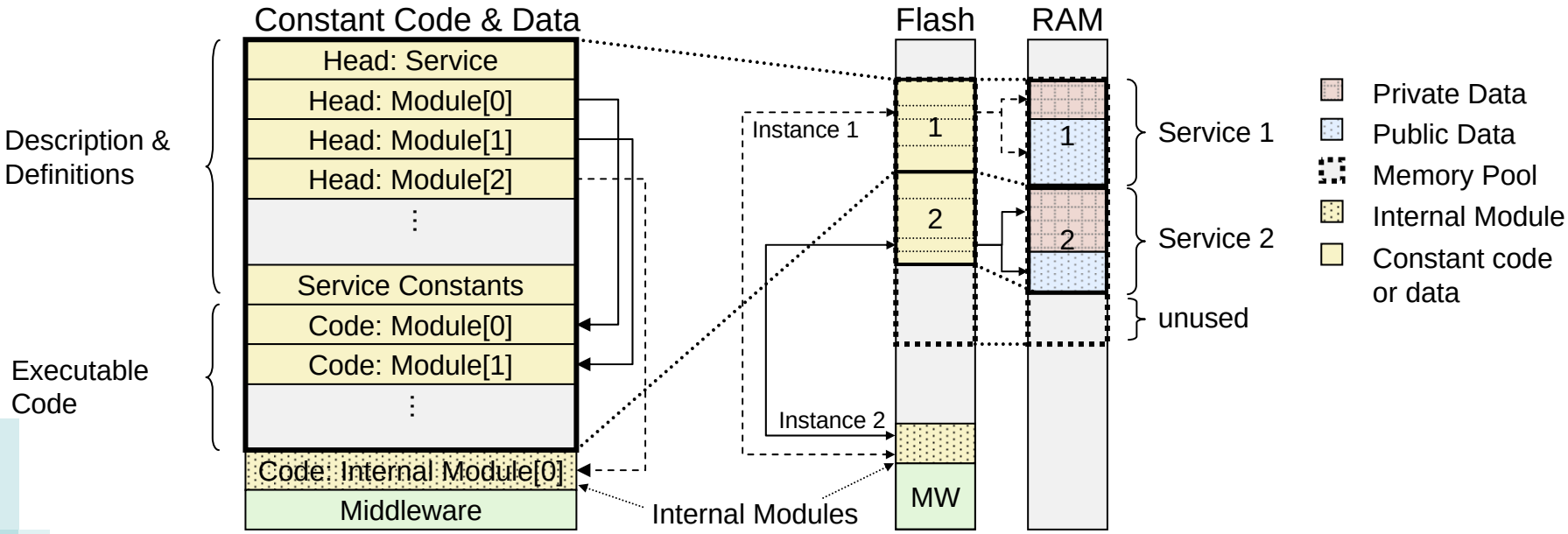
Internal Modules

- *Outsourcing* of most used parts into node's middleware, e.g. group building
- Internal module description:
  - is abstract
  - defines a link to an already existing internal module
- Data memory of internal module is mapped to service memory



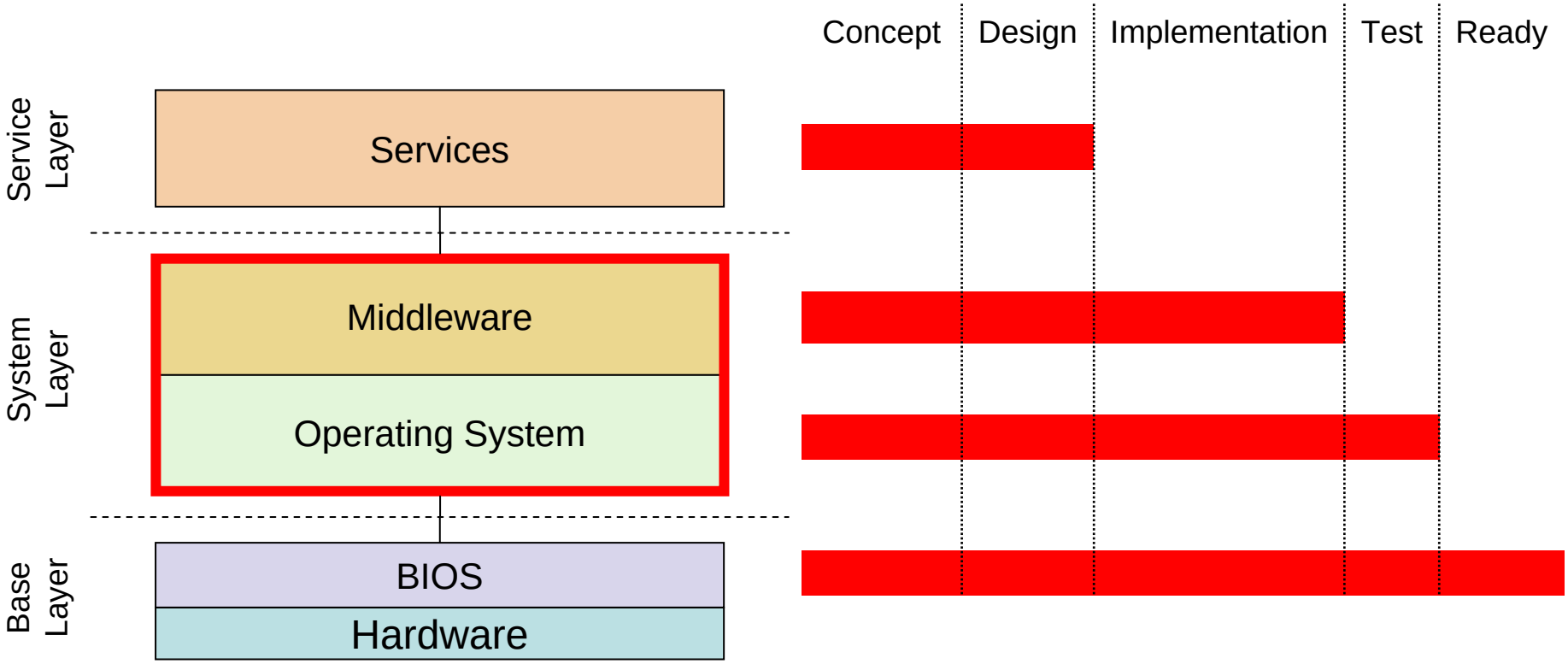
Memory Organization: *Chipcon CC1010*

- Harvard-Architecture (Chipcon CC1010, 8051 Microcontroller)
- Two service instances (instance 1 and instance 2)
- Both instances reference to the internal Module[0] and provide a part of its own data memory to internal module[0]



Current State

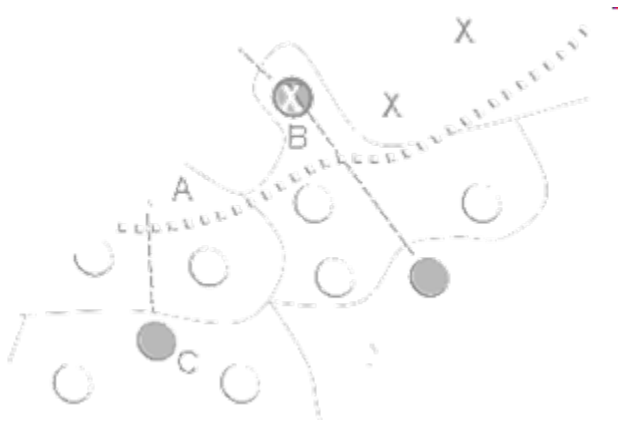
Implementation



Conclusion

Service-oriented software architecture supporting

- Dynamical updates/requests
- Mappable to different memory architectures of microcontrollers
- Simple interfaces and protocols
- Collaboration of nodes
- Robustness and self-healing effects



Thank You!

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