MIDDLEWARE GROUP COMMUNICATION MECHANISMS IN M2M ENVIRONMENTS

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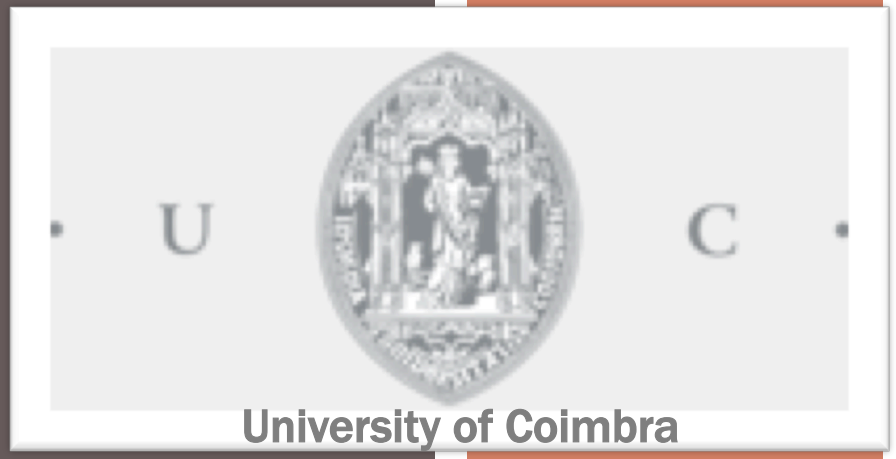


OUTLINE

- General problems to address in M2M
- Requirements to fulfill addressing these problems
- Goal definition
- Specific problem to attack
- Proposal
- Future works

GENERAL PROBLEMS TO ADDRESS IN M2M

- *Base-station overload*
  - In M2M communication a huge number of M2M devices may try to connect at the same point in time [1]
- *Energy consumption of devices*
  - M2M communication involves resource-constrained devices, which have low power resources
- *Heterogeneous applications*
  - M2M applications must be aware about the events detected by other applications

[1] 3GPP: System improvements for machine-type communications. V0.5.1. (July 2010) Technical Report 23.888

REQUIREMENTS TO FULFILL ADDRESSING THESE PROBLEMS

- *Avoid the base-station overload*
  - If overload occurs, the communication with all requested devices will not be possible, damaging the M2M communication as well as the traditional Human-to-Human (H2H) communication

- *Prolong the lifetime of the constrained-resource devices*
  - Without an appropriate use of the devices' energy, these devices will need human maintenance, which increases operational costs and reduce the network lifetime

REQUIREMENTS TO FULFILL ADDRESSING THESE PROBLEMS

- *Reduce the application programming complexity and enable high level of abstraction*
  - Reduce the costs with programming and enabling the interaction of different applications from different stakeholders
- *Manage multiple (heterogeneous) application interests*
  - The M2M heterogeneity implies in multiple data types
  - Applications with different amount of traffic, frequency of transmissions and delay tolerance
- *Be adapted dynamically according to the level of resources available in the devices involved in the communication*

GOAL DEFINITION

General Problems	Requirements	Main Goal
P1: Base-station overload	R1: Avoid Base-station overload	Design a dynamical middleware component to satisfy multiple application interests, managing **mechanisms** that save energy and avoid base-station overload
P2: Devices' energy consumption	R2: Prolong the lifetime of the constrained-resource devices R3: Be adapted dynamically according to the level of resources available in the devices involved in the communication	
P3: Heterogeneous applications	R4: Manage multiple (heterogeneous) application interests R5: Reduce the application programming complexity and enable high level of abstraction	

GOAL SPECIFICATION

- Main goal:

  "Design a dynamical middleware component to satisfy multiple application interests, managing mechanisms that save energy and avoid base-station overload"

- The potential mechanisms to be used:
  - Data-aggregation
  - Sleep-schedule
  - Uplink-schedule
  - Signaling-aggregation

- The management of these mechanisms:
  - Takes into account the heterogeneous applications requests, the base-station overload indicators and the M2M devices' status

SPECIFIC PROBLEMS TO ATTACK

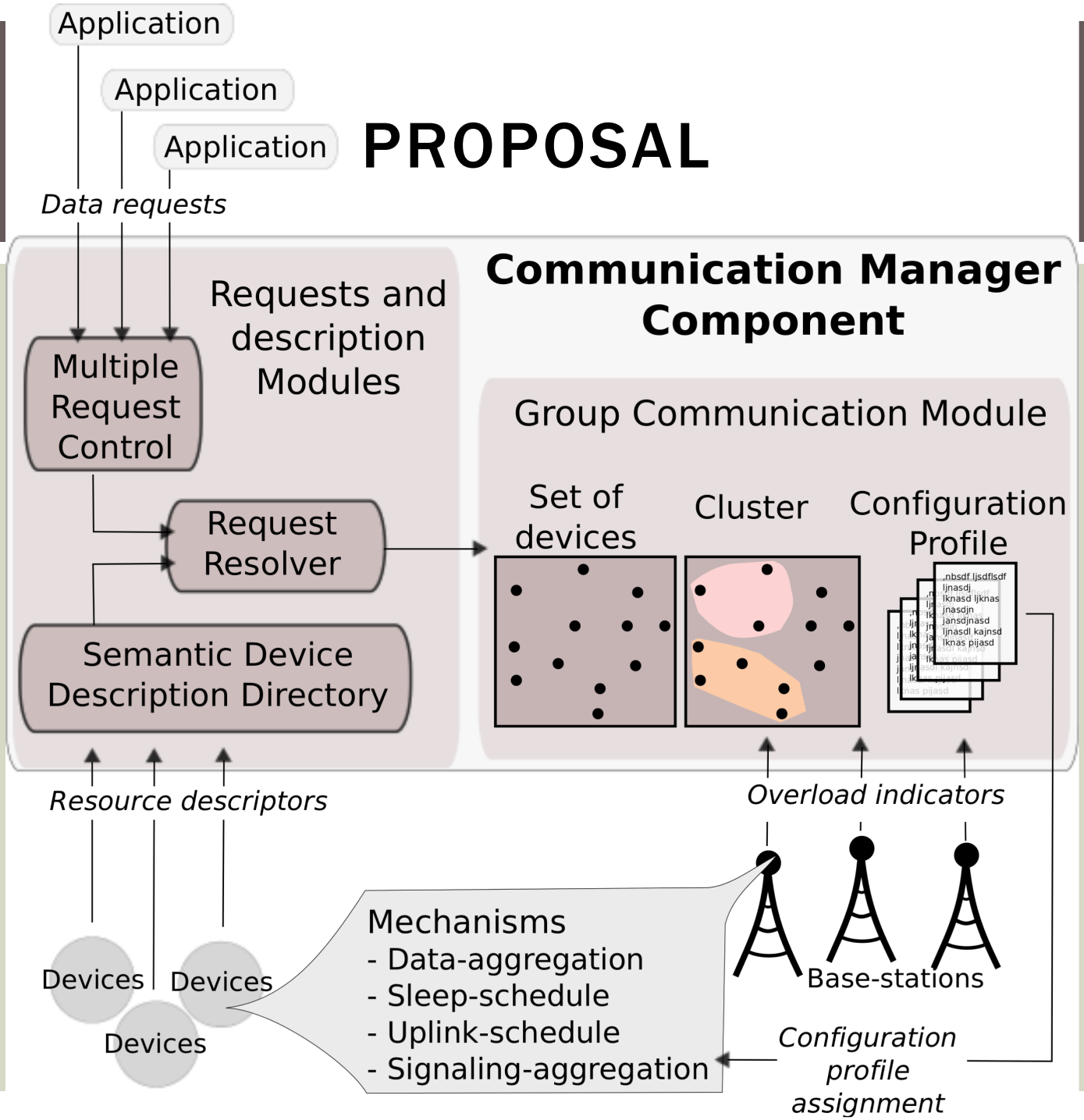
- A solution involving these four mechanisms should consider how each mechanism affects the others
- Data-aggregation vs Sleep-schedule
  - The delay problem
    - Delay is a special issue considering the following applications: *real-time monitoring*, including e-healthcare, smart grids, environmental monitoring, industrial automation, and so on [10].
    - The delay caused by the sleep added to the delay caused by the data-aggregation can break the application tolerance
  - The multi-hop problem
    - In a multi-hop scenario, the sleep-schedule mechanisms can break the data-aggregation path

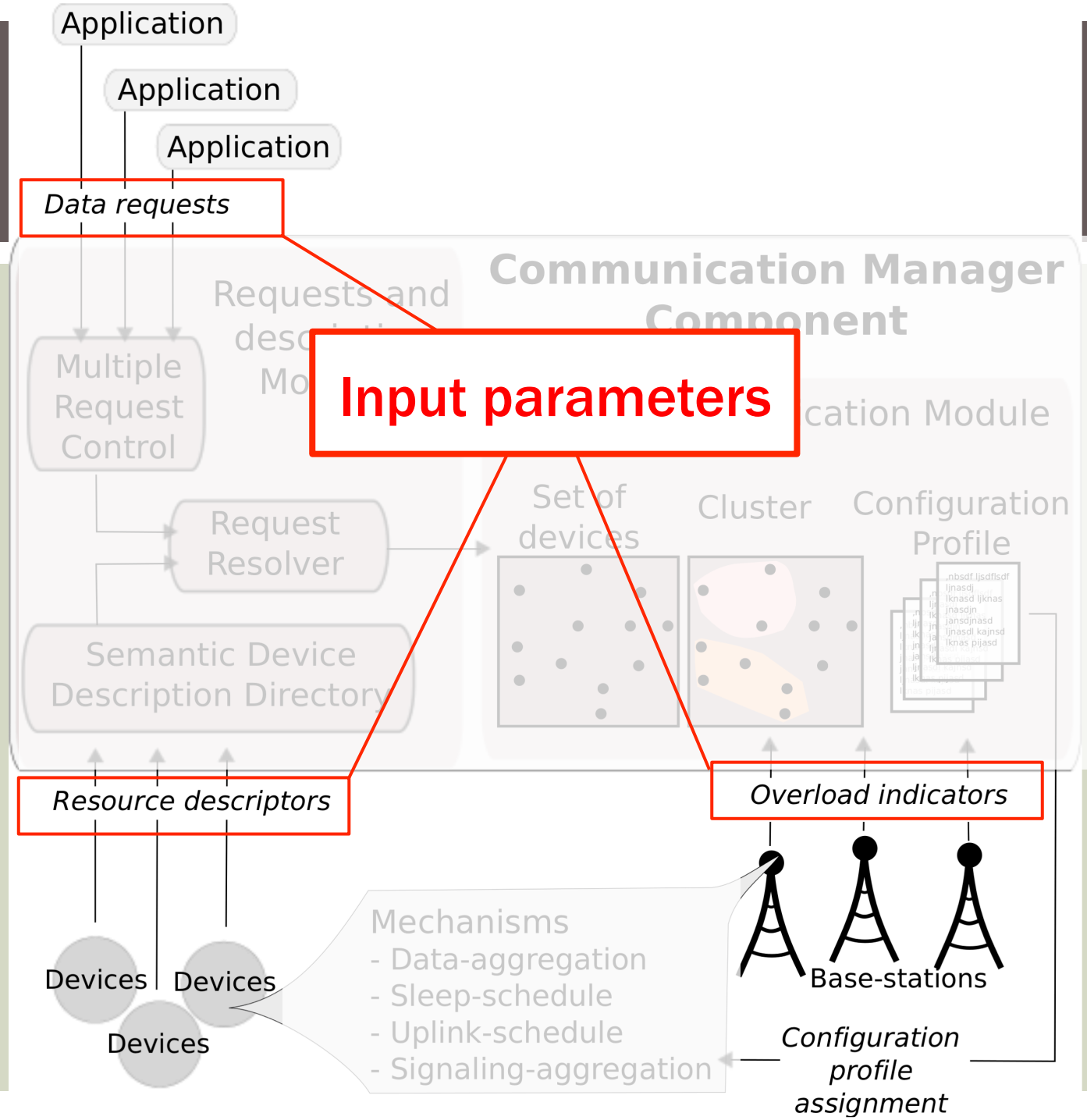
[10] Lu, R., Li, X., Liang, X., Shen, X., and Lin, X., "GRS: The Green, Reliability, and Security of Emerging Machine to Machine Communications," *IEEE Communications Magazine*, vol. 49, pp. 28– 35, April 2011.

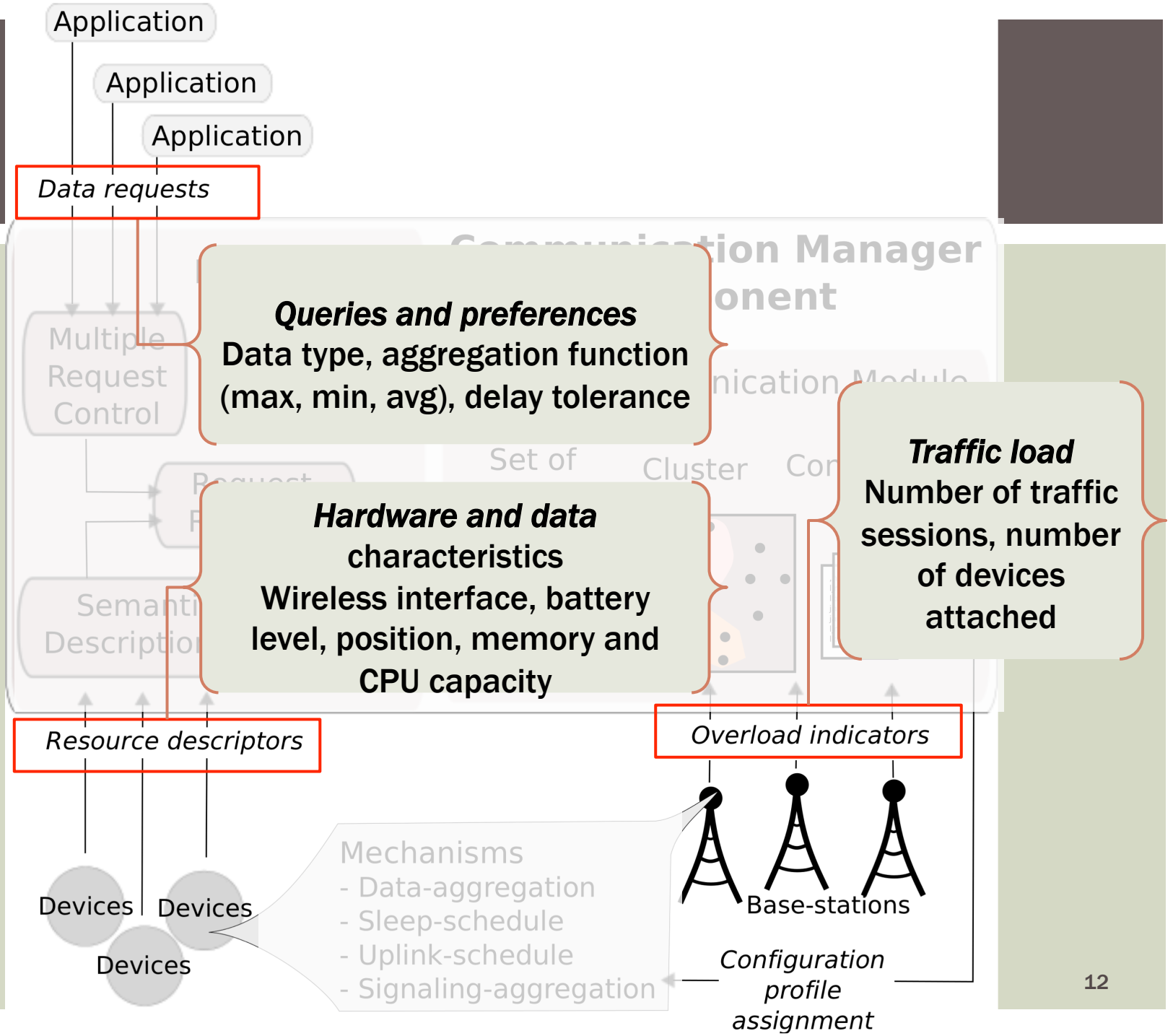
SPECIFIC PROBLEMS TO ATTACK

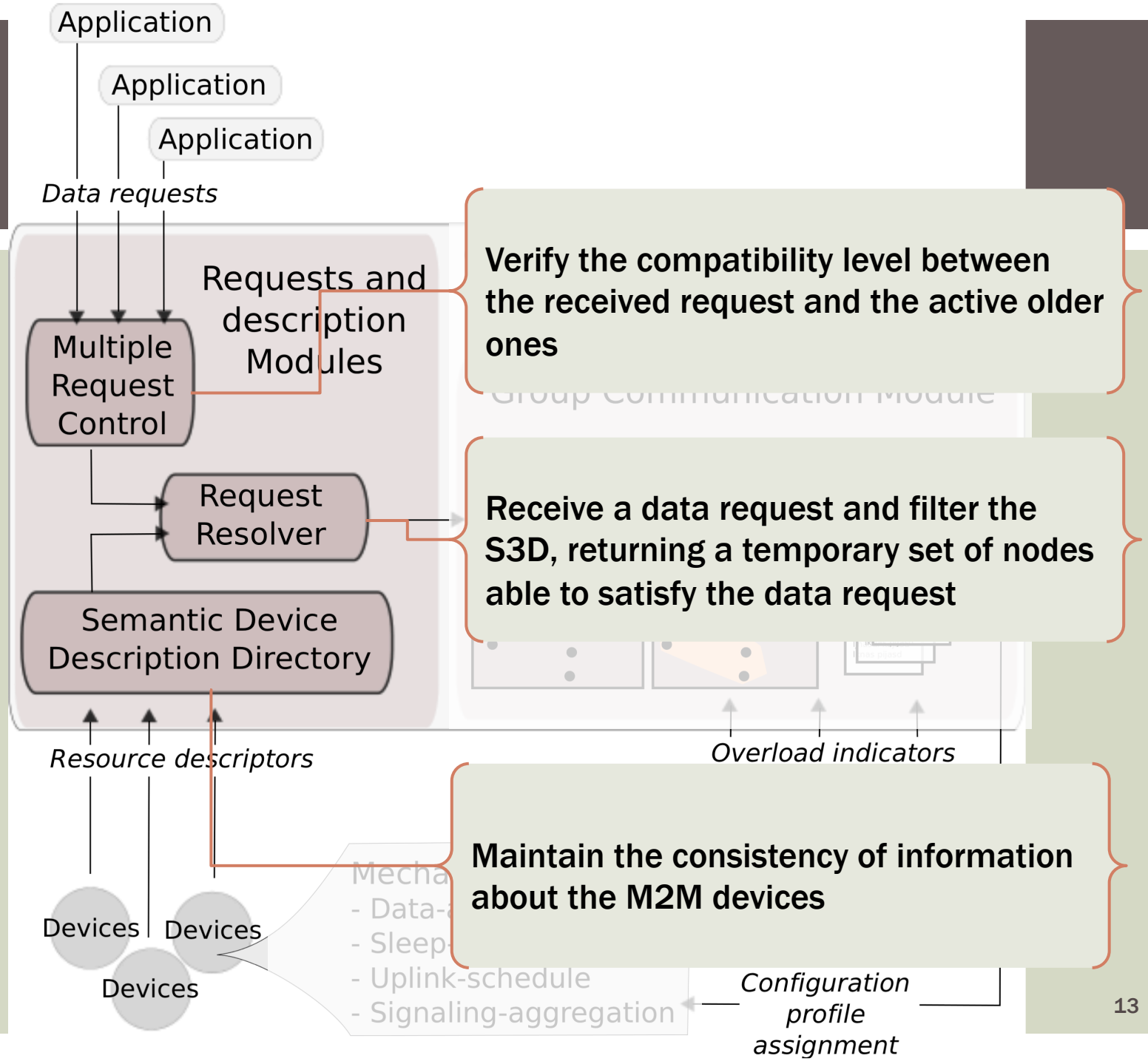
- Data-aggregation and sleep-schedule versus Signaling-aggregation and uplink-schedule
  - Synchronization problem
    - Without synchronization the next transmission could be scheduled to a period that the device is in sleep mode, which means that no transmission will occur and no signaling message will be send

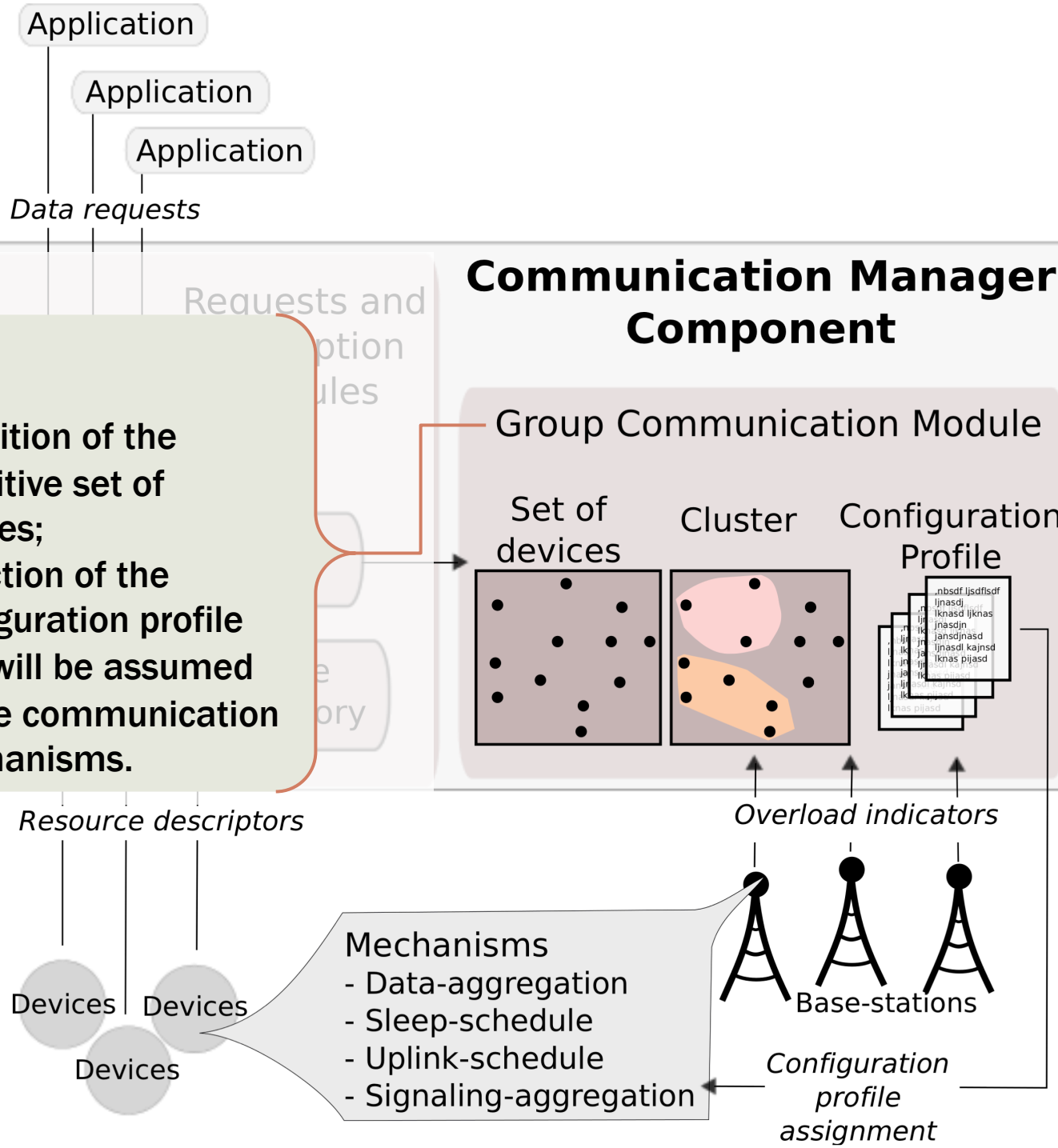
PROPOSAL


Application
Application
Application
Data requests
Requests and description Modules
Multiple Request Control
Request Resolver
Semantic Device Description Directory
Communication Manager Component
Group Communication Module
Set of devices
Cluster
Configuration Profile
Resource descriptors
Overload indicators
Devices
Devices
Devices
Mechanisms
- Data-aggregation
- Sleep-schedule
- Uplink-schedule
- Signaling-aggregation
Base-stations
Configuration profile assignment


Application
Application
Application
Data requests
Communication Manager Component
Requests and
Multiple Request Control
Input parameters
cation Module
Request Resolver
Set of devices
Cluster
Configuration Profile
Semantic Device Description Directory
Resource descriptors
Overload indicators
Devices
Devices
Devices
Mechanisms
- Data-aggregation
- Sleep-schedule
- Uplink-schedule
- Signaling-aggregation
Base-stations
Configuration profile assignment


Application
Application
Application
Data requests
Multiple Request Control
Queries and preferences
Data type, aggregation function (max, min, avg), delay tolerance
Hardware and data characteristics
Wireless interface, battery level, position, memory and CPU capacity
Traffic load
Number of traffic sessions, number of devices attached
Resource descriptors
Overload indicators
Devices
Devices
Devices
Mechanisms
- Data-aggregation
- Sleep-schedule
- Uplink-schedule
- Signaling-aggregation
Base-stations
Configuration profile assignment


Application
Application
Application
Data requests
Requests and description Modules
Multiple Request Control
Request Resolver
Semantic Device Description Directory
Verify the compatibility level between the received request and the active older ones
Receive a data request and filter the S3D, returning a temporary set of nodes able to satisfy the data request
Maintain the consistency of information about the M2M devices
Resource descriptors
Overload indicators
Devices
Devices
Devices
- Uplink-schedule
- Signaling-aggregation
Configuration profile assignment


Application
Application
Application
Data requests
Communication Manager Component
Group Communication Module
Set of devices
Cluster
Configuration Profile
Tasks:
1) Definition of the definitive set of devices;
2) Selection of the configuration profile that will be assumed by the communication mechanisms.
Resource descriptors
Overload indicators
Devices
Devices
Devices
Mechanisms
- Data-aggregation
- Sleep-schedule
- Uplink-schedule
- Signaling-aggregation
Base-stations
Configuration profile assignment

FUTURE WORKS

- Group definition metrics and profile configuration
  - Several metrics can be used to select the devices that will communicate
    - E.g.: Best level of energy, best location, best sensor accuracy, best bandwidth
  - Several configuration profiles can be assigned to the mechanisms
    - E.g. 1: Configure the data-aggregation to have low energy consumption and high delay. Simultaneously, the sleep-schedule can be configured to generate high energy consumption and low delay.
    - E.g. 2: Configure both mechanisms to have low energy consumption and high communication delay

FUTURE WORKS

- Study other mechanisms that could be added to the 4 mechanisms
- Design of the rules/polices for the decision tasks
- Study the overhead impact of the proposed component versus the benefits