Politecnico di Bari

SISINF LAB

SWoT Semantic Web of Things

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Smart Buildings e Comunità Energetiche

Intelligenza Artificiale per Edifici Intelligenti

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OUTLINE

- Ambient Intelligence
- Artificial Intelligence for Energy Communities
  - Multi-level Architecture
  - Technological Solutions
  - Home-level Knowledge-based Framework
- Social Framework for Smart Objects
- Argumentative Social Objects
- Future work directions

AMBIENT INTELLIGENCE

Classic Domotics

- Static and not flexible architectures
- Constrained interoperability
- Reduced functionalities and scenarios
- User-driven interaction (low autonomicity)

Agent-based Domotics

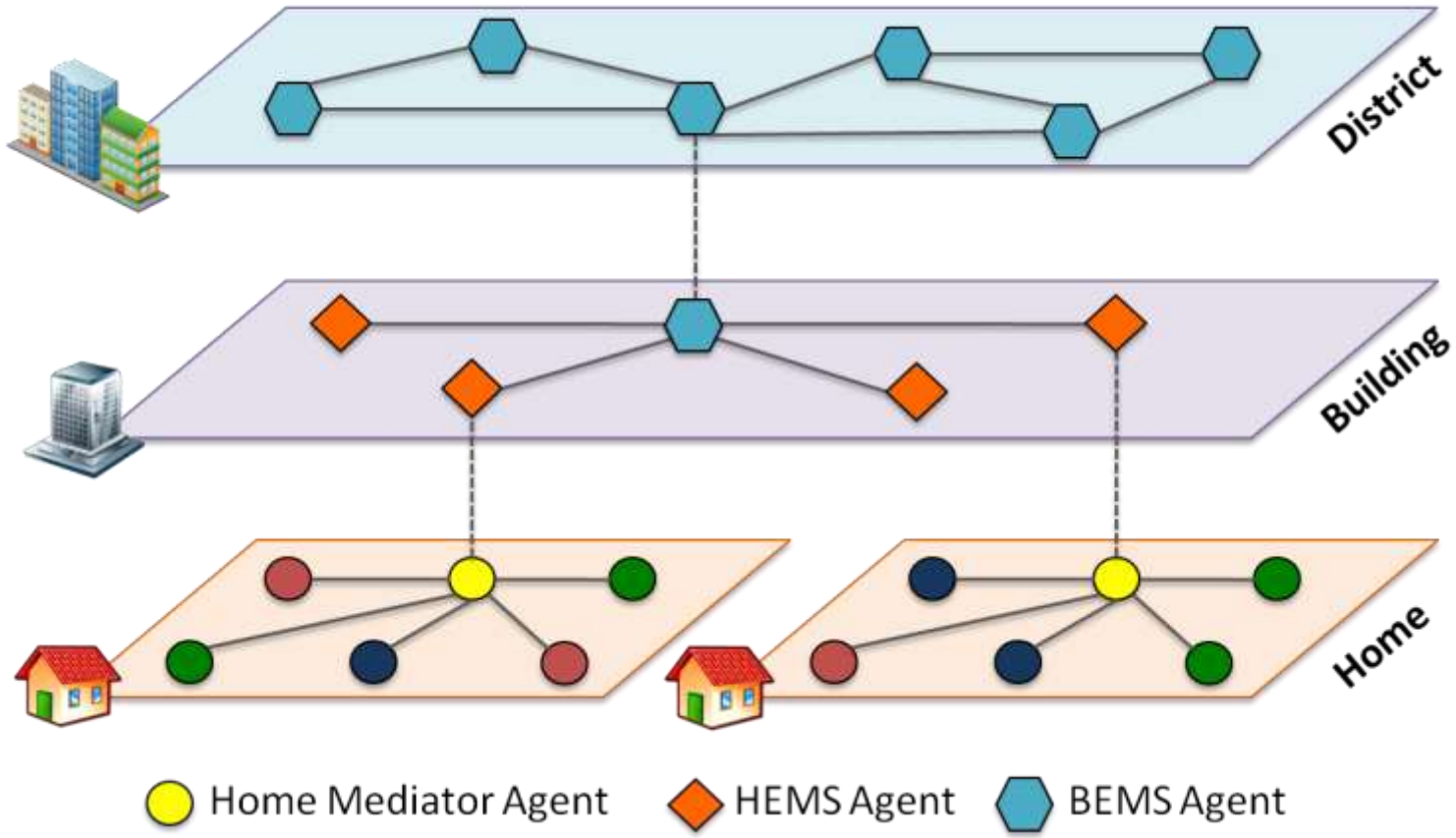
- Flexible and scalable
- Services and resources accessible via agent-oriented frameworks
- Concurrency, cooperation, negotiation enabled

Semantic-based Domotics

- Improved interoperability
- Rich description of user/service profiles
- Decentralized architecture supporting autonomous device-driven interactions

MULTI-LEVEL AGENT FRAMEWORK \ ENERGY COMMUNITIES

Framework architecture for home, building and district energy management in a Smart Grid vision *[Ruta et al., IEEE TII, 2014]*



TECHNOLOGICAL SOLUTIONS

Semantic-based enhancement of HBA protocol standards

- integration of a semantic micro-layer preserving a full backward compatibility
- advanced service and resource discovery support

Logic-based negotiation process to:

- select one or more functionalities whose combination fills the user/device request
- negotiate on available home and energy resources through a user-transparent and device-driven interaction
- discover the (set of) elementary services that maximize an overall utility
- support non-expert users in selecting home configurations ranked w.r.t. a global utility

Goal

- Increase comfort and building efficiency
- Decrease waste and maintenance costs
- Integration of different home systems

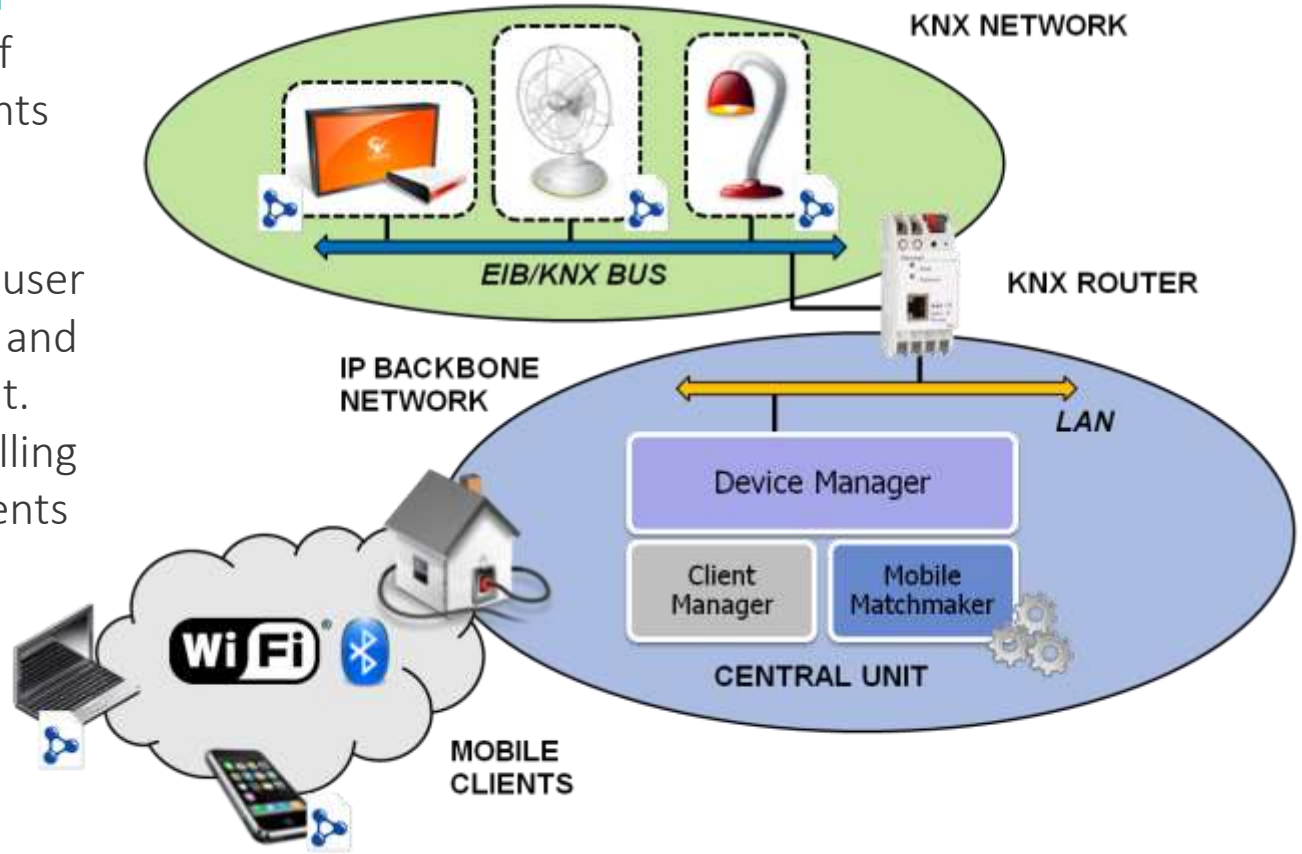
Most important HBA standards

- ZigBee (HA Profile)
- Lonworks
- X-10
- EIB/KNX (low cost, widespread, ethernet support)

HOME-LEVEL ARCHITECTURE

Semantic-based enhancement of EIB/KNX protocol *[Ruta et al., IEEE TII, 2011]*

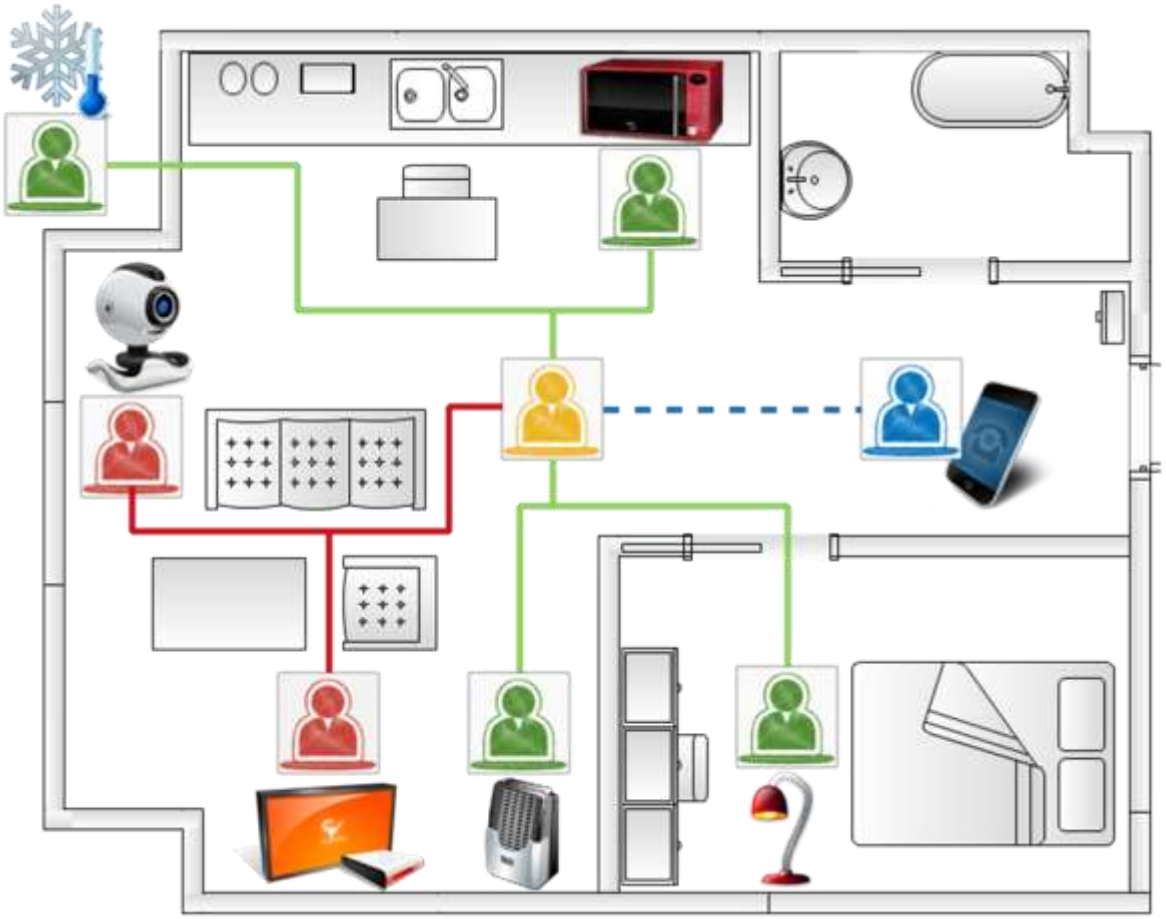
- home self-configuration through collaboration of autonomous smart agents
- semantic annotation of user profiles, device settings and appliance behaviors w.r.t. an OWL ontology modelling typical home environments



- perform a multimodal (i.e., involving several heterogeneous data sources) and continuous sensing without human intervention
- mine user habits automatically
- build a logic-based daily profile exploited in context-aware HBA applications

HOME AGENT FRAMEWORK

Exploiting the semantic-based enhancement of EIB/KNX protocol *[Ruta et al., IEEE TII, 2014]*



User Agent
(WiFi communication)

exposes user needs and preferences

Mediator Agent

acts as a mediator in a negotiation round

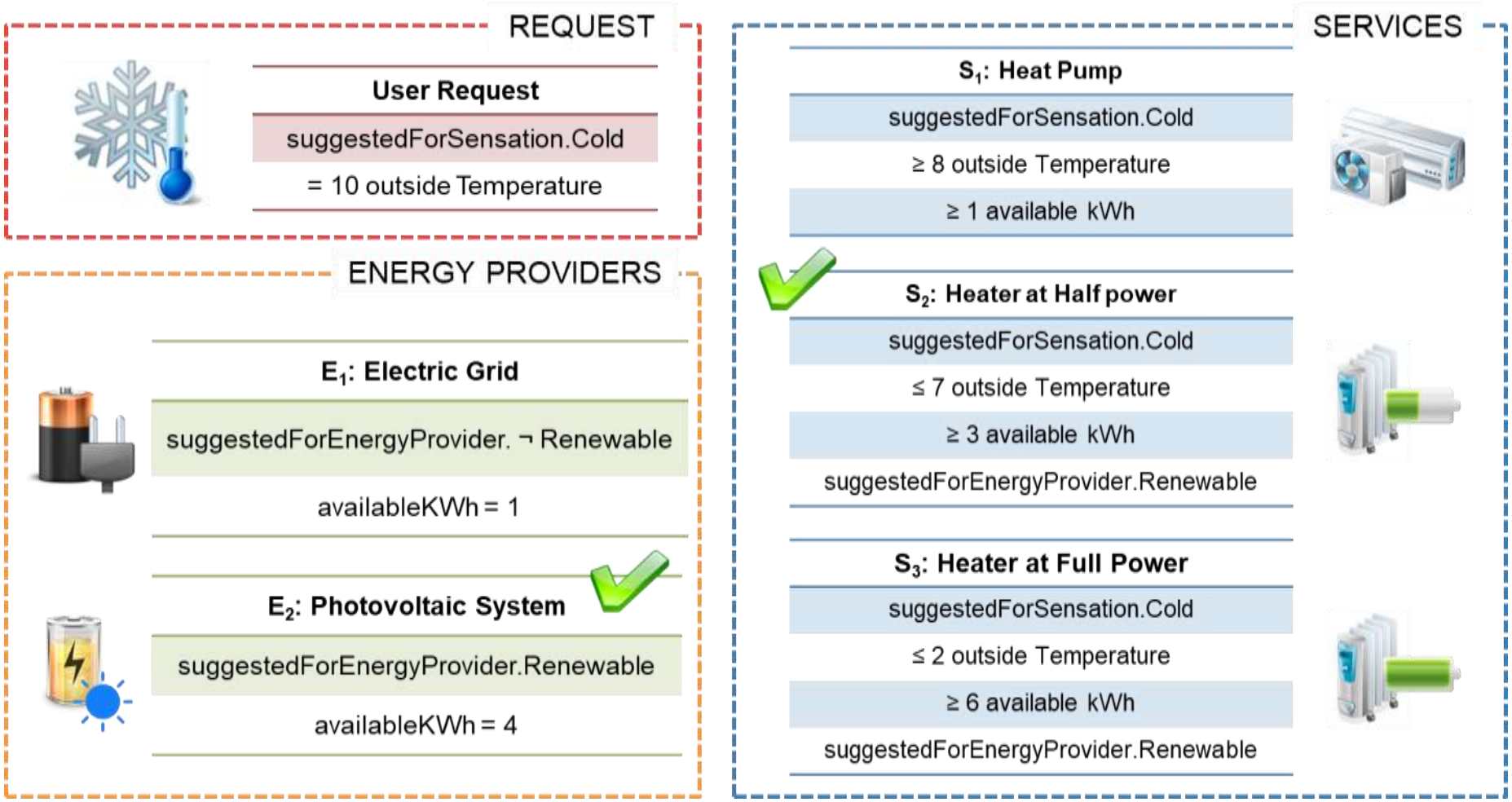
KNX Device Interface Agent
(Semantic enhanced KNX protocol)

supports KNX enhancements in case of legacy appliances

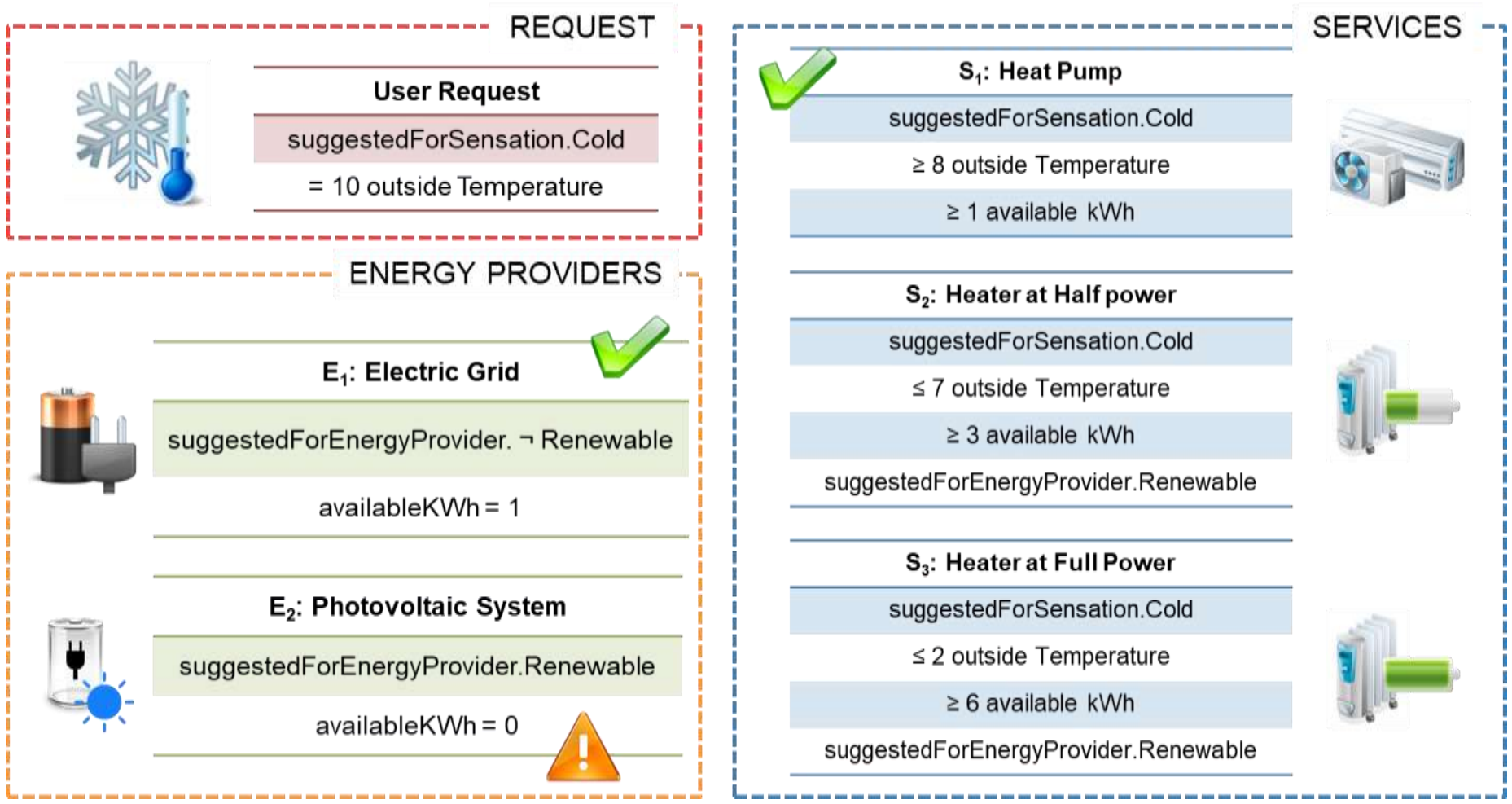
Smart Device Agent
(Direct communication over IP network)

sends semantic-based requests to the mediator agent for negotiating a home profile

Select service and energy provider by compatibility and efficiency



What happens if energy storage is empty?



SOCIAL FRAMEWORK FOR SMART OBJECTS *[Ruta et al., Semantic Web, 2018]*

Social Multi-Agent network 

- full peer-to-peer service-oriented architecture
- interaction paradigms borrowed from social networks
- different message propagation models based on event priorities

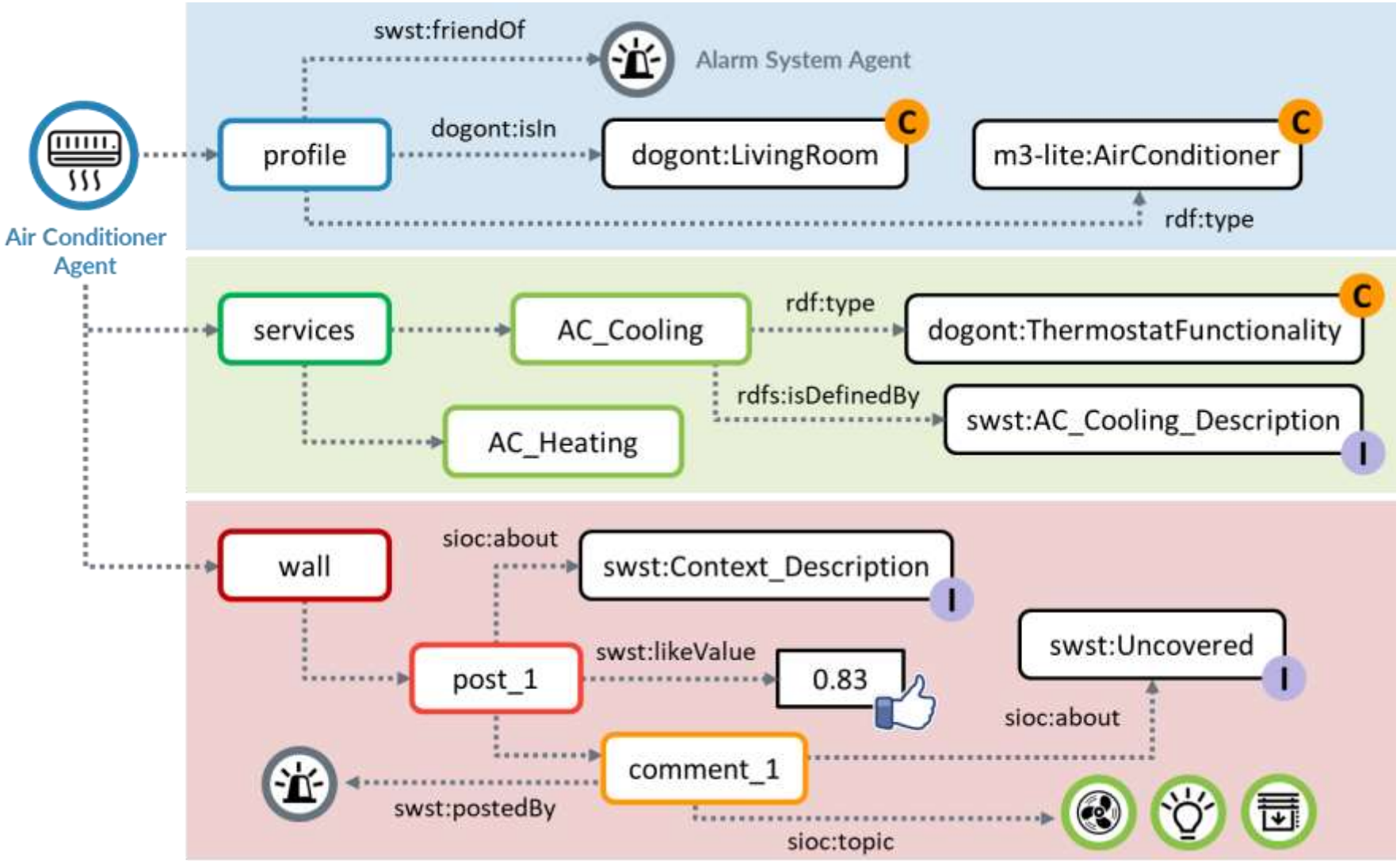
Social entities and relationships

- following/friendship criteria verified by means of a matchmaking process
- both push and pull models supported for agents' communication

Relationships 

- friendship → request friend's services, activate/deactivate friend's services
- following → receive friend's updates, unidirectional relationship

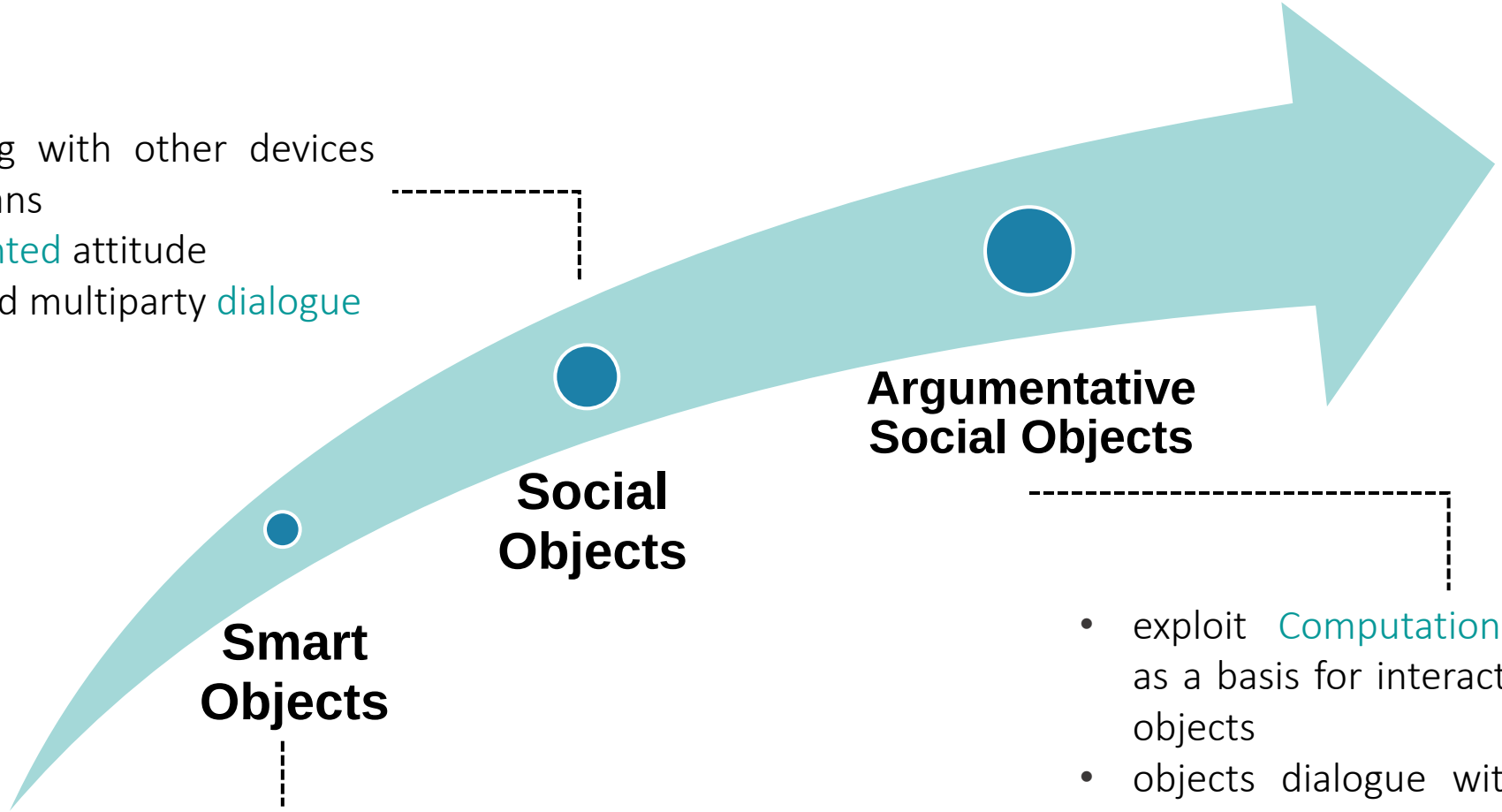
SMART OBJECT MODELING



- social interaction
- distributed service discovery
- wall, post, comment
- tag & like

ARGUMENTATIVE SOCIAL OBJECTS

- interacting with other devices and humans
- goal-oriented attitude
- distributed multiparty dialogue

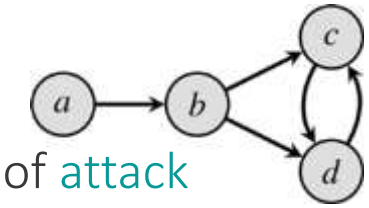


- collect information by observing the world
- perform specific actions in their environment
- reasoning and processing data capabilities

- exploit Computational Argumentation as a basis for interactions among social objects
- objects dialogue with each other by arguing their perceptions
- cooperative autonomous decision making

ARGUMENTATION

Argumentation Framework *[P. M. Dung, Artificial Intelligence, 1995]*



- Graph-based formalism to reason over conflicting knowledge
- Does not consider the internal structure of the arguments, but only their relationships of attack
- Adopts semantics for evaluating the arguments' acceptability in a formal manner

Argumentation in Social IoT

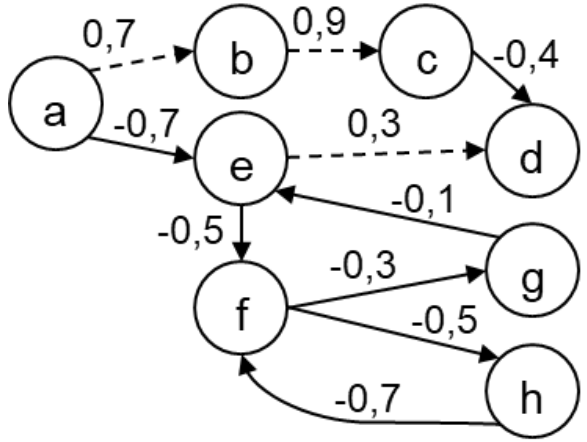
- Dynamic object interactions as argumentative graph
- Coordination, cooperation and competition among devices
- Decentralized autonomous decision making

Expected benefits

- Truthfulness of the information collected
- Reliability and explainability of the decisions suggested by the devices
- Adaptability to context changes

Bipolar Weighted Argumentation Framework *[Fasciano et al., SWEET @ ICWE 2022]*

- Incorporates Bipolar AF and Weighted AF
- Allows relations of weighted attack and weighted support between arguments
- Assigns a positive (respectively negative) weight to each support (resp. attack)



Interpretable BWAF

- Associate a logic-based annotation to each device
- Each annotation takes the role of an argument in the BWAF
- Appraisal of the type and weight of each relationship between device pair by means of semantic matchmaking
- Gradual semantics: assigns a numerical weight to explicitly rank each argument according to its degree of acceptability
- Identification of the most acceptable action(s) to be performed in the scenario

APPRAISAL OF ARGUMENTATIVE RELATIONS

Leveraging automated reasoning services

1. Compatibility check

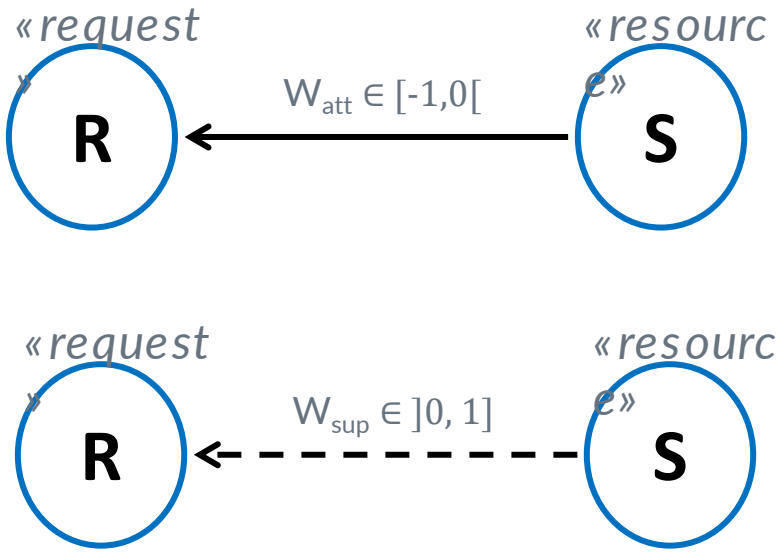
- Success → support relation
- Fail → attack relation

2. Weighting of attack relations

- conflicting information between the two arguments
- information confirmed by both arguments
- additional information in the attacked argument
- any additional information in the attacker

3. Weighting of support relations

- Information lacking to reach a full match
- Any additional information in the supporter



FUTURE WORK DIRECTIONS

- Artificial intelligence techniques to increase the efficiency of energy communities
- Digital twin of energy communities in the electric grid for real-time visualization of energy consumption and generation
- Advanced management of grid and non-grid renewable energy systems
- Careful experimentation of novel enabling technologies and close collaboration with citizens
- Make consumers as independent as possible from the distribution grid
- Smart contracts via blockchain for automated processing of transactions within energy communities

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