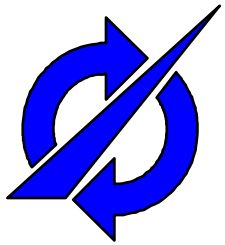
ruSMART 2015
August 26-27, 2015. St.-Petersburg, Russia



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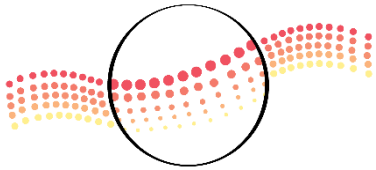

Multi-Level Robots Self-Organization in Smart Space: Approach and Case Study

Alexander Smirnov, Alexey Kashevnik, Sergey Mikhailov,
Mikhail Mironov, Olesya Baraniuc

St.Petersburg Institute for Informatics and Automation RAS (SPIIRAS), Russia
ITMO University, St.Petersburg, Russia
Technopark of ITMO Univercity, St.Petersburg, Russia

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Introduction

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- Increasing number of devices with built-in processors and data storage possibilities (more than **50 billions** of devices, more than **5 billions** of smartphones will be available in **10 years**).
- **Self-organizing systems** are characterized by their capacity to **spontaneously** (without external control) **produce a new organization** of environmental changes.
- **Self-organization of robots** requires cyber-physical infrastructure allowing robots to **operate in physical part** while their **interaction** has to be organized in **cyber part**.
- **Cyber-physical systems** are **physical and engineered systems** whose operations are integrated, monitored, and/or **controlled** by a **computational core**. Components are **networked** at every scale. Computing is deeply embedded into every physical component, possibly even into materials. The computational core is an embedded system, usually demands **real-time response**, and is most often distributed.

Introduction: Cyber-Physical System

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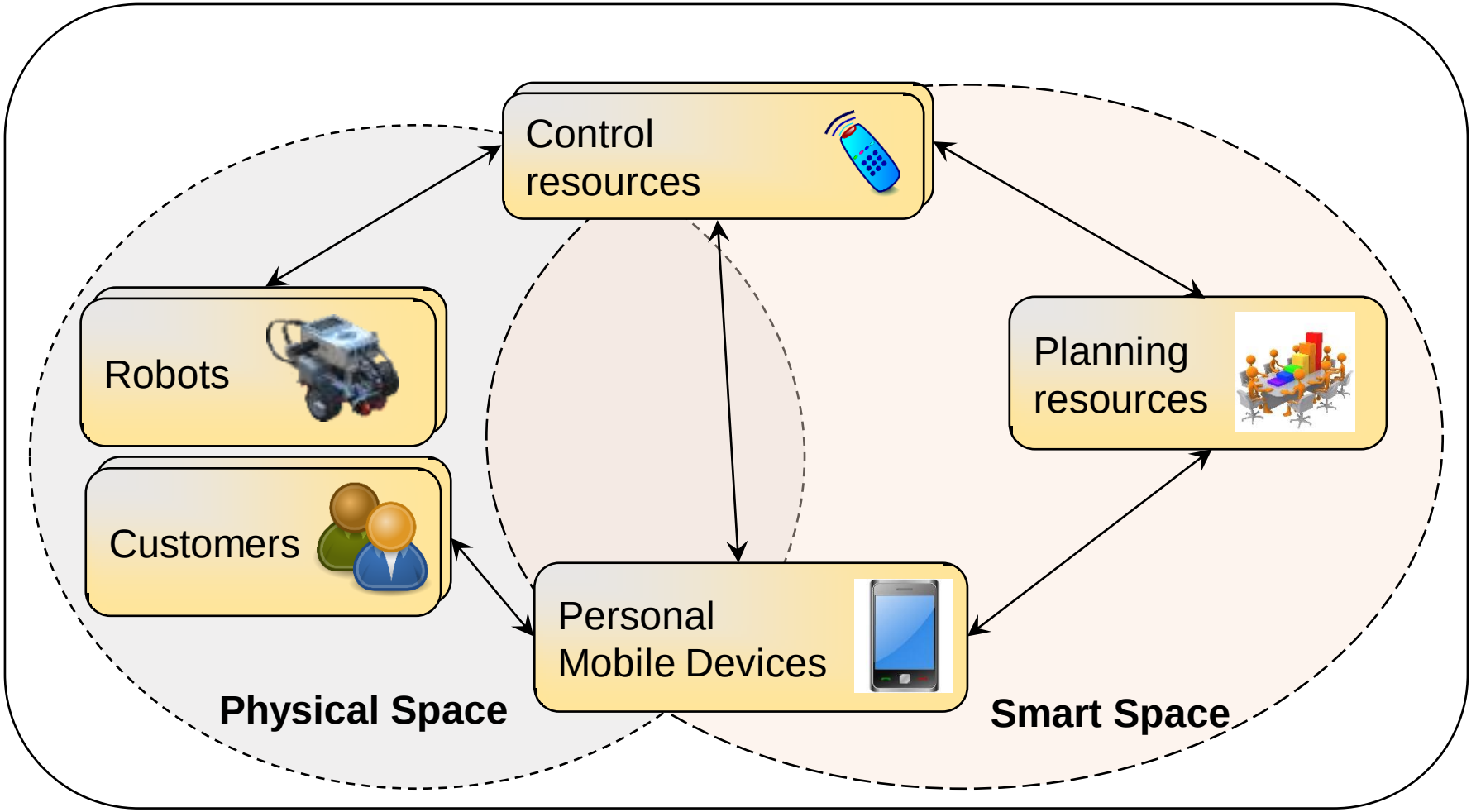
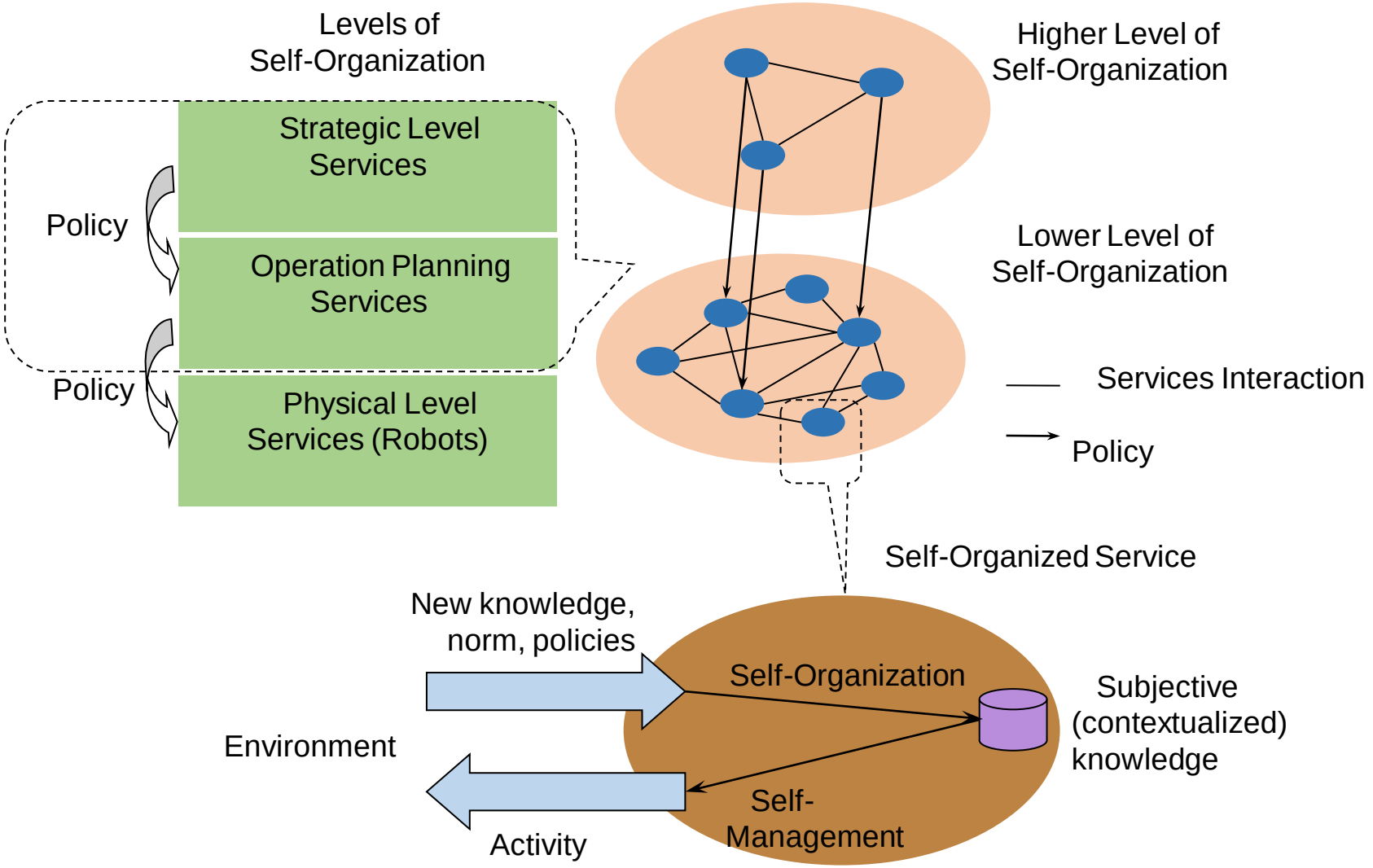


Approach:
Multi-Level Robots Self-Organization



Approach: Ontology-Based Robots Interaction in Smart Space

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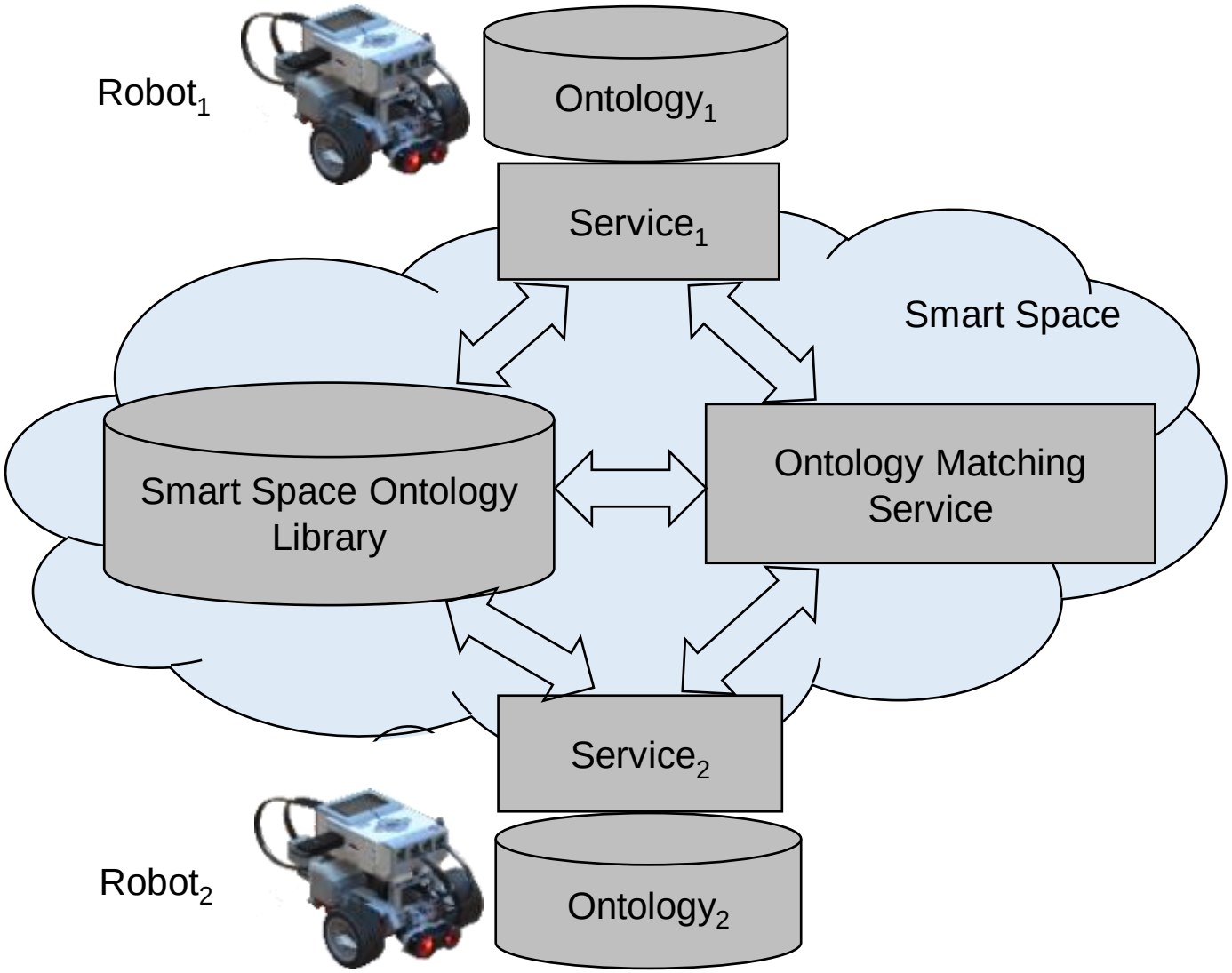

Robot Ontologies: Manipulating Robot

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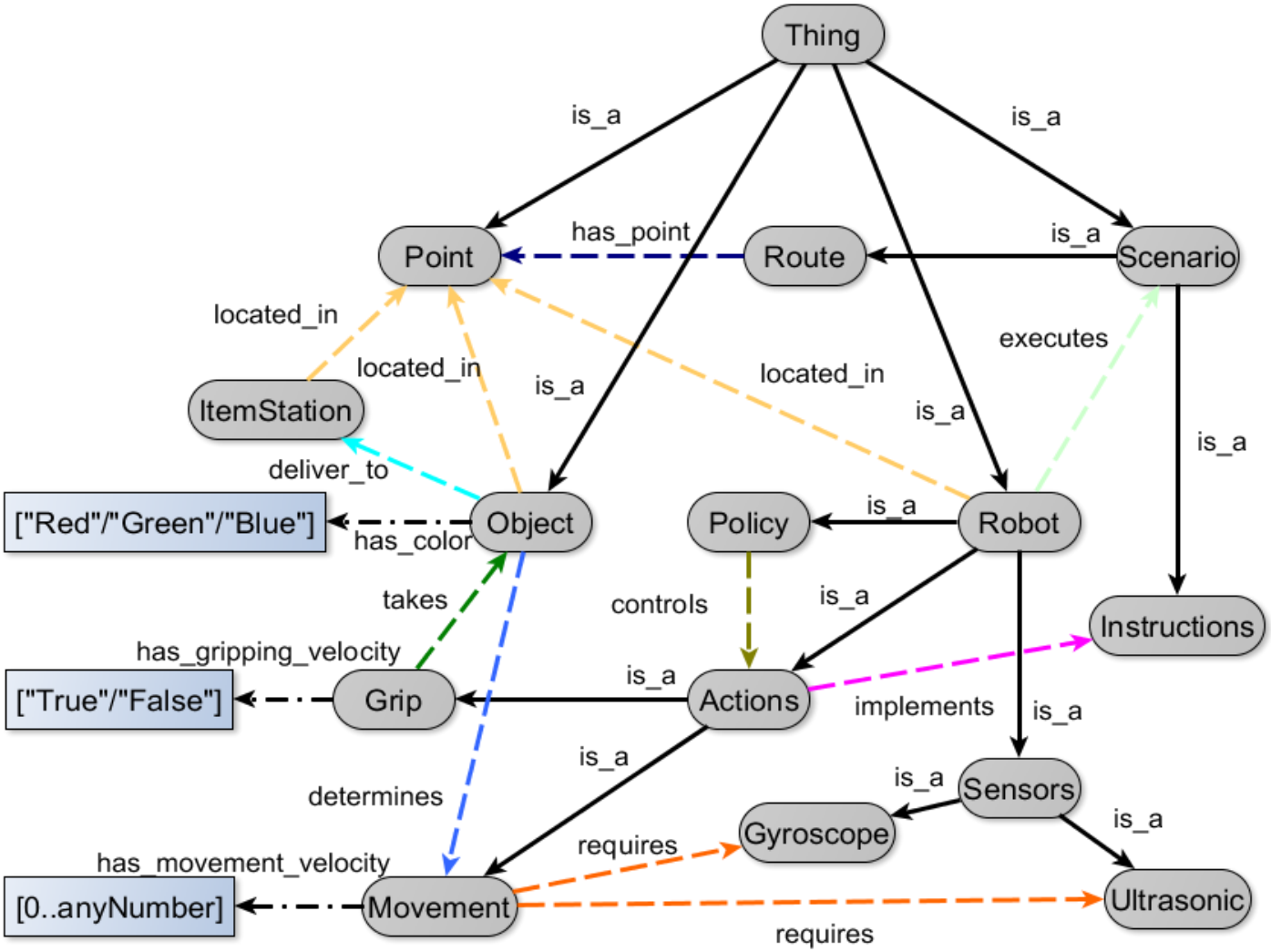
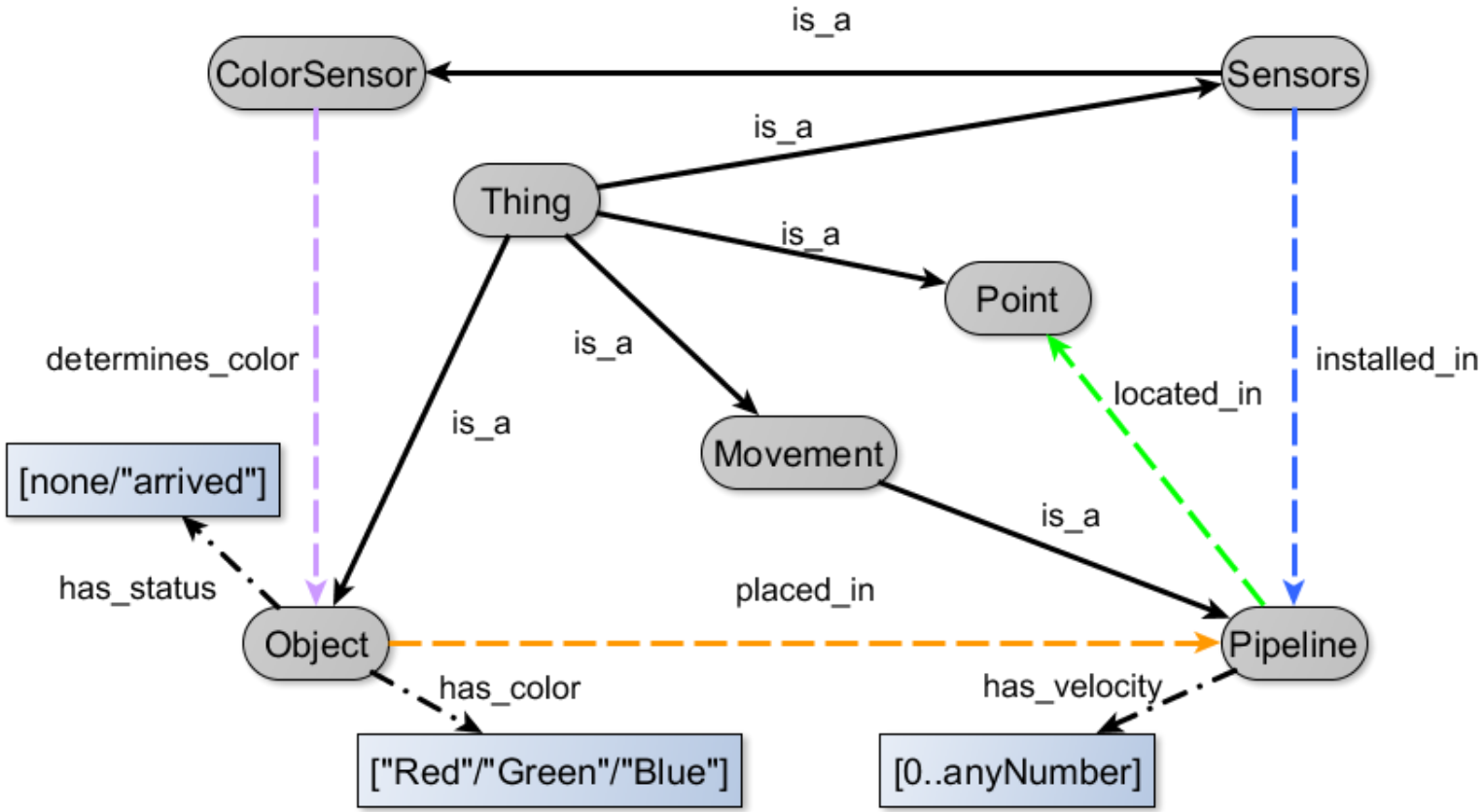


Robot Ontologies: Pipeline Robot Ontology



Implementation: Scenario Description (1)

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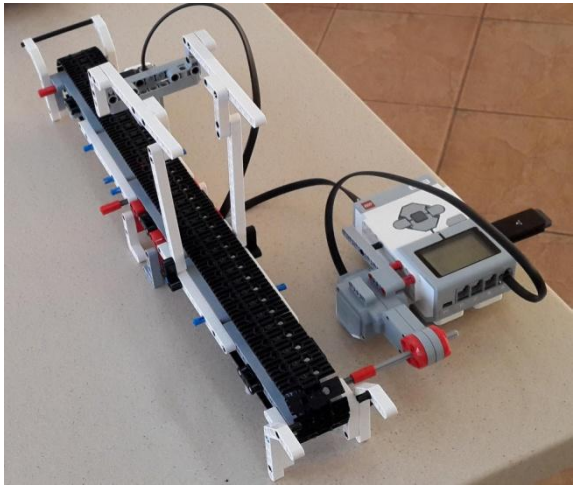
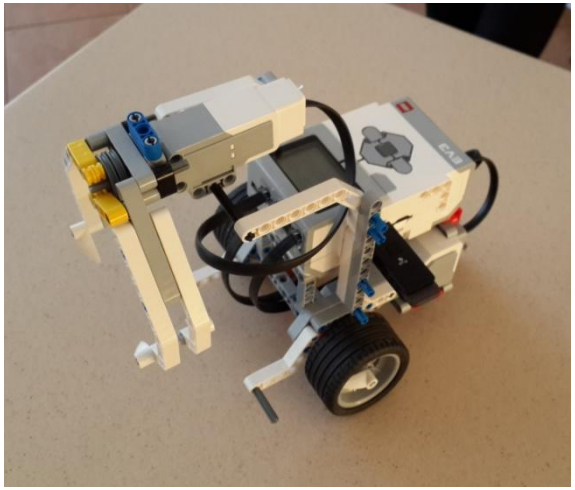
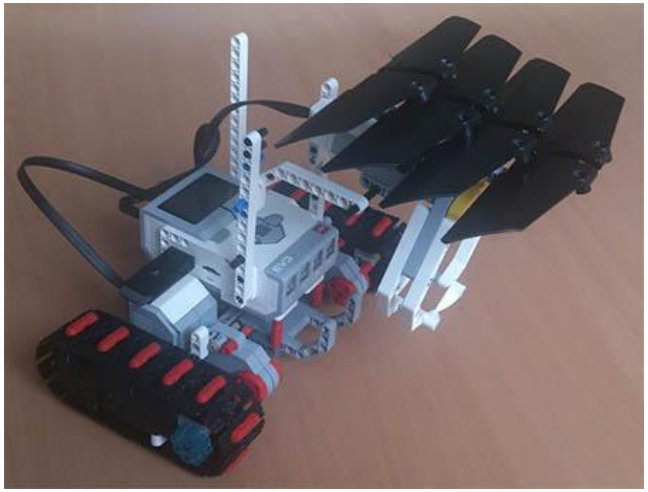
- The system solves the task of pick-and-place an object from one point to another
- Three types of robots participate in the system scenario:
  - Pipeline Robot (can scan object's characteristics, can provide the object to the end of pipeline).
  - Fast Manipulating Robot (can take the object and move it to another place based on object's characteristics).
  - *Water Resistant* Manipulating Robot (extends Fast Manipulating Robot by roof which covers object in case of rain).



Pipeline Robot



Fast Manipulating Robot



Water Resistant Manipulating Robot

Implementation:
Scenario Description (2)

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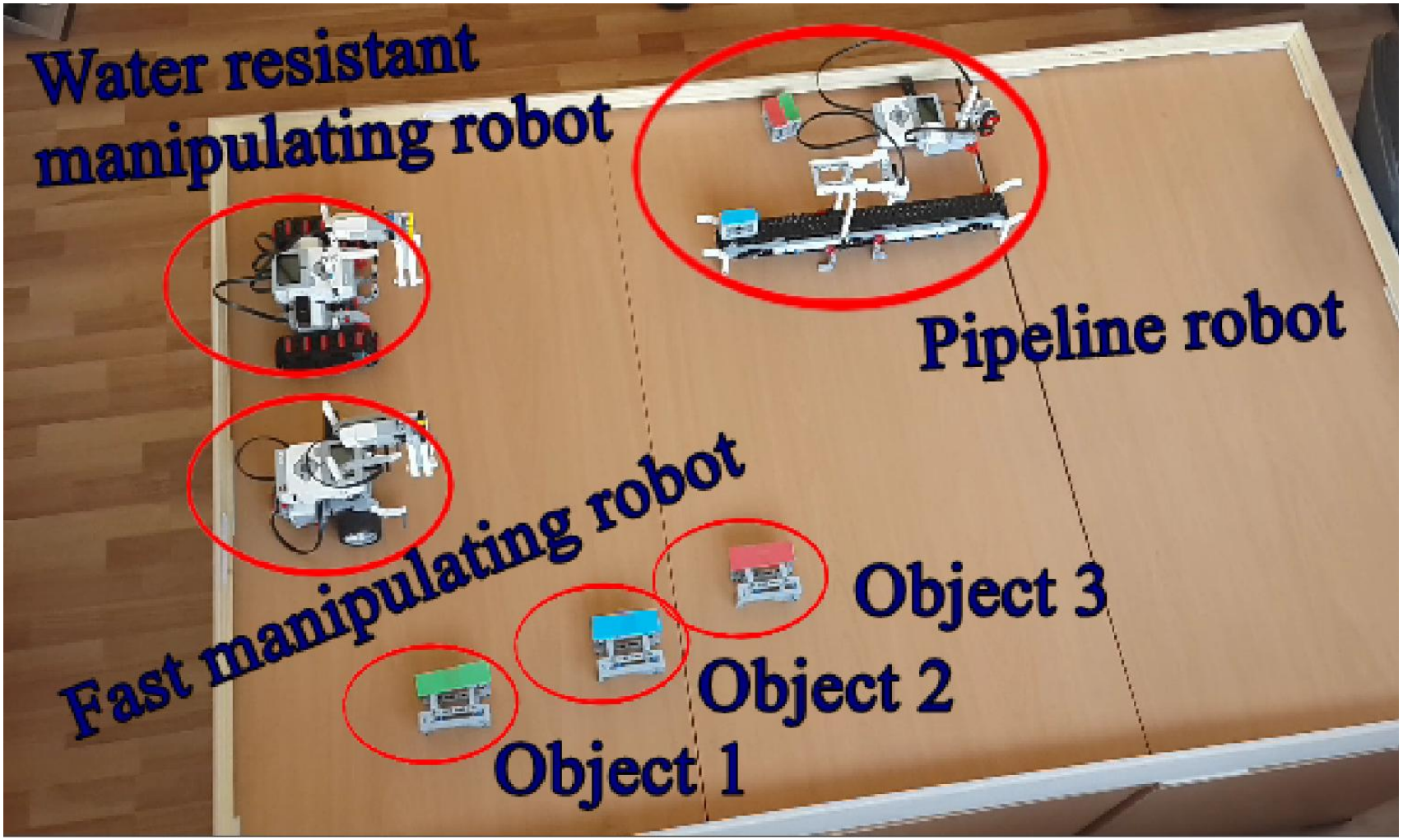
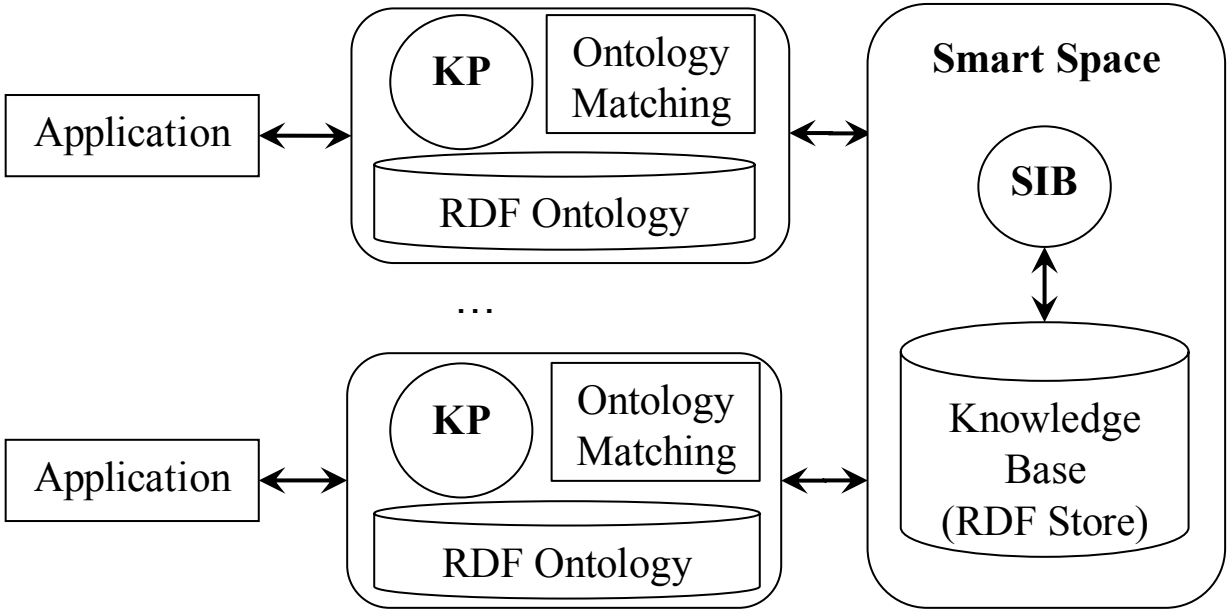


Implementation: Smart-M3 Information Sharing Platform

- Smart-M3 includes:
  - SIB: Devices and software entities (applications) **can publish their embedded information** for other devices and software entities through simple, shared Semantic Information Brokers.
  - The interface for managing information in the SIB is provided by Knowledge Processors (KP)
- The understandability of information is based on the usage of the **common RDF ontology** models and common data formats.



- Smart-M3 allows user KP to:
  - add,
  - remove,
  - change, and
  - subscribe,

on information in SIB.

Implementation: RDF-Based Example of Robots Interaction

When the robot is moving the object, the pipeline velocity is shared with smart space by the following triple in according with the presented bellow pipeline robot ontology.

- *(“Pipeline”, “has_velocity”, [pipeline velocity])*

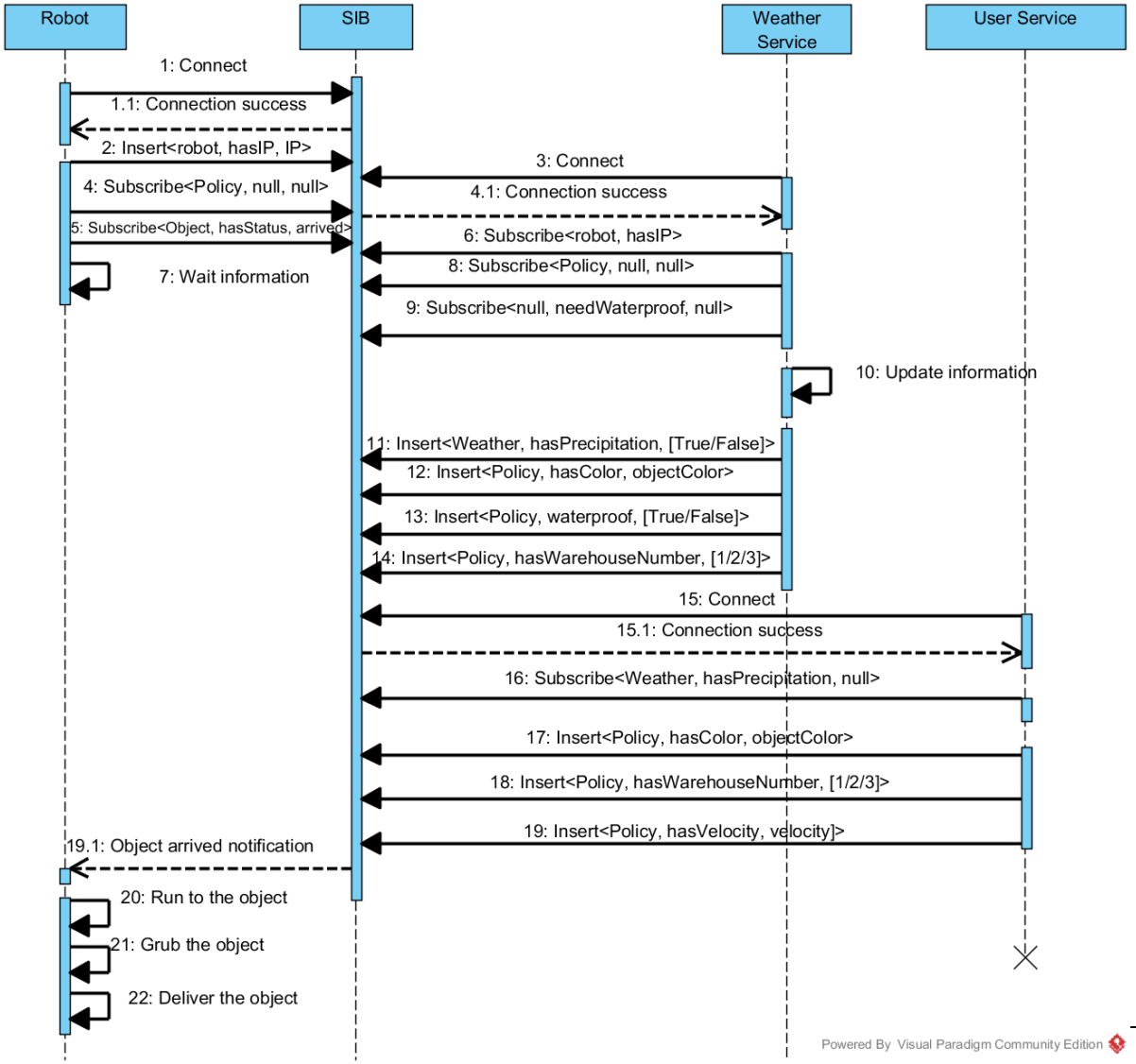
When the color is determined, it is shared with smart space by the following way.

- *(“Object”, “has_color”, [object color])*

When the object has been moved to the destination point and is ready for manipulation by the manipulating robot, the related triple is shared with smart space by pipeline robot.

- *(“Object”, “is_ready_for_manipulation”, 1)*
- *(“Pipeline”, “has_velocity”, 0)*

Implementation: Sequence Diagram of Robot and Service Interaction



Scenario

Pick-and-place an object from pipeline to warehouse.

Conclusion

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- An approach and case study implementation for robots self-organization in smart space have been presented.
- Developed approach allows to self-organize smart space participants in different levels, three levels have been proposed (physical level for the robots, operation planning level for the operational service and strategic level for the services which form the strategy of the case study) and two levels have been implemented.
- Implementation is based on Smart-M3 information sharing platform that provides possibilities of information sharing based on Semantic Web.

Thank you for Attention. Questions are Welcome

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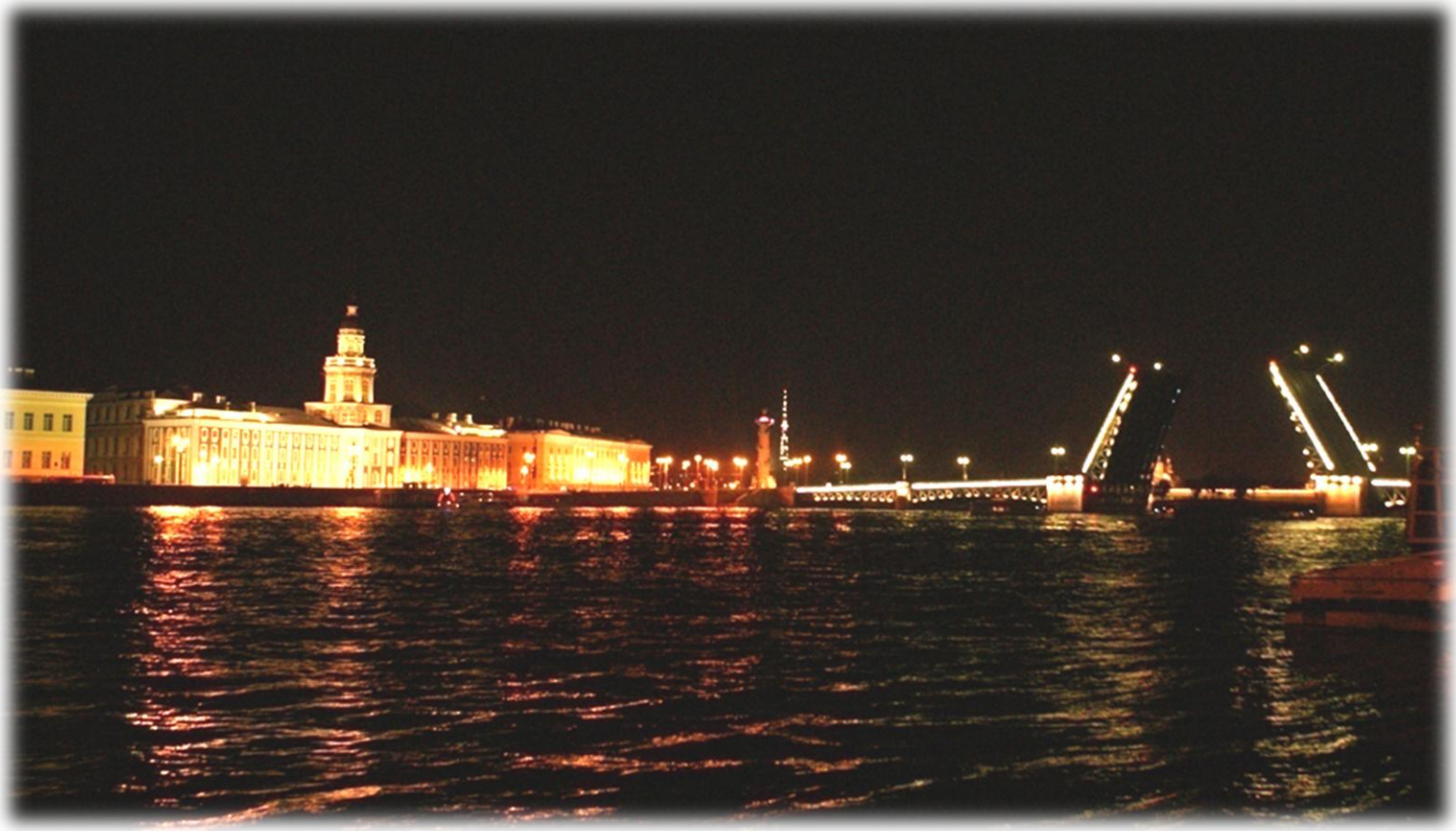

Alexey Kashevnik, PhD
St. Petersburg, Russia, E-mail: alexey@iias.spb.su