Arrowhead Framework in Big Physics

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Pan-European research infrastructure (RI)

- Relevance of Research infrastructure (RI)
  - ESFRI (European Strategic Forum on Research Infrastructures)
  - Scientific excellence: fundamental and applied research
  - Pan-European relevance
  - Socio-economic impact
  - Technology transfer and economic enabler

- Impact on economy
  - Enterprises use RI
  - Enterprises can be a high-tech supplier of RI
  - Innovation network around RI (industrial- academic cooperation)

Pan-European research infrastructure (RI)

- ESFRI Roadmap projects (48)
  - Establishment and operation by more than one state
  - International collaboration
  - Delivery of subsystems by several companies

- Examples of research infrastructure
  - CERN (+sLHC + ILC)
  - ESS (Neutron): Lund, spallation neutron source
  - JET: largest European fusion system
  - ELI: extreme light infrastructure (HU, CZ, RO), European laser-center of highest intensity

- The RIs are built from **various different subsystems**
- The RIs are utilized by research communities with **legacy information and control systems**

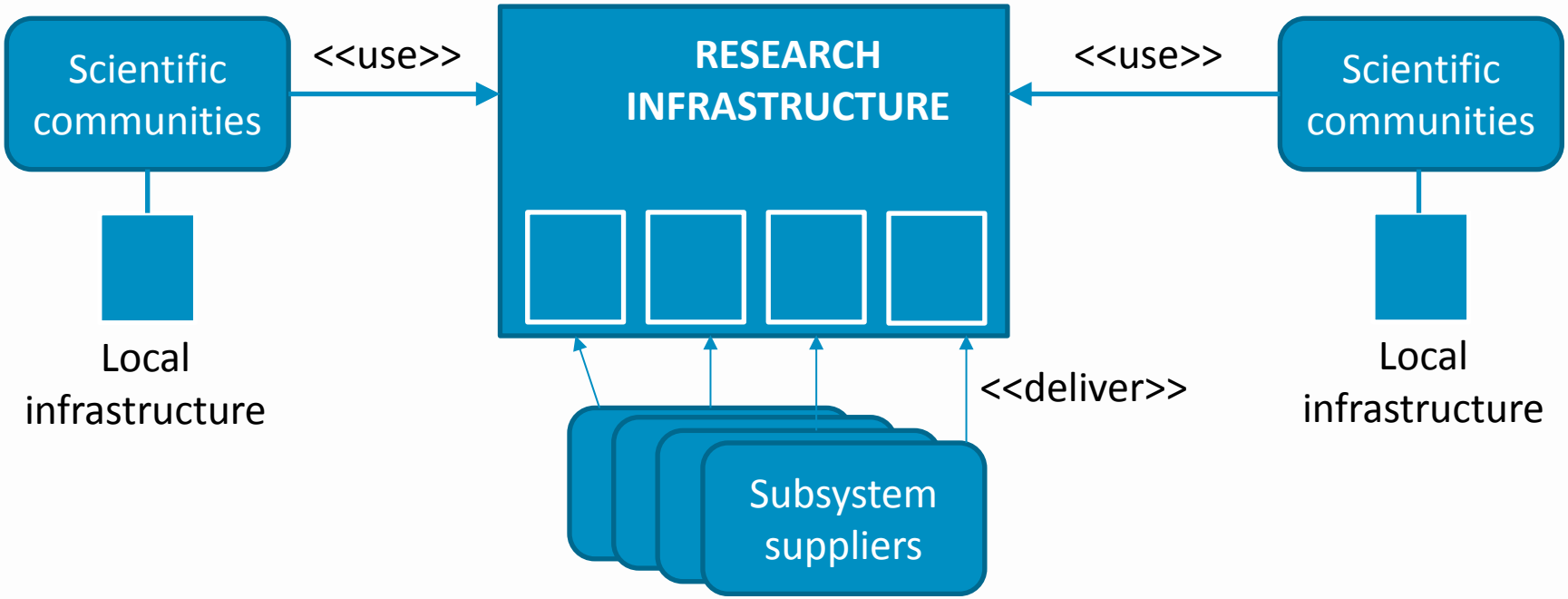
Pan-European RI

Problem statement

- **The integration problem in research infrastructure**:
  - Integration of different subsystems
  - Integration of supplied components of various technology
  - Integration of control
  - Support simulation for planning experiments

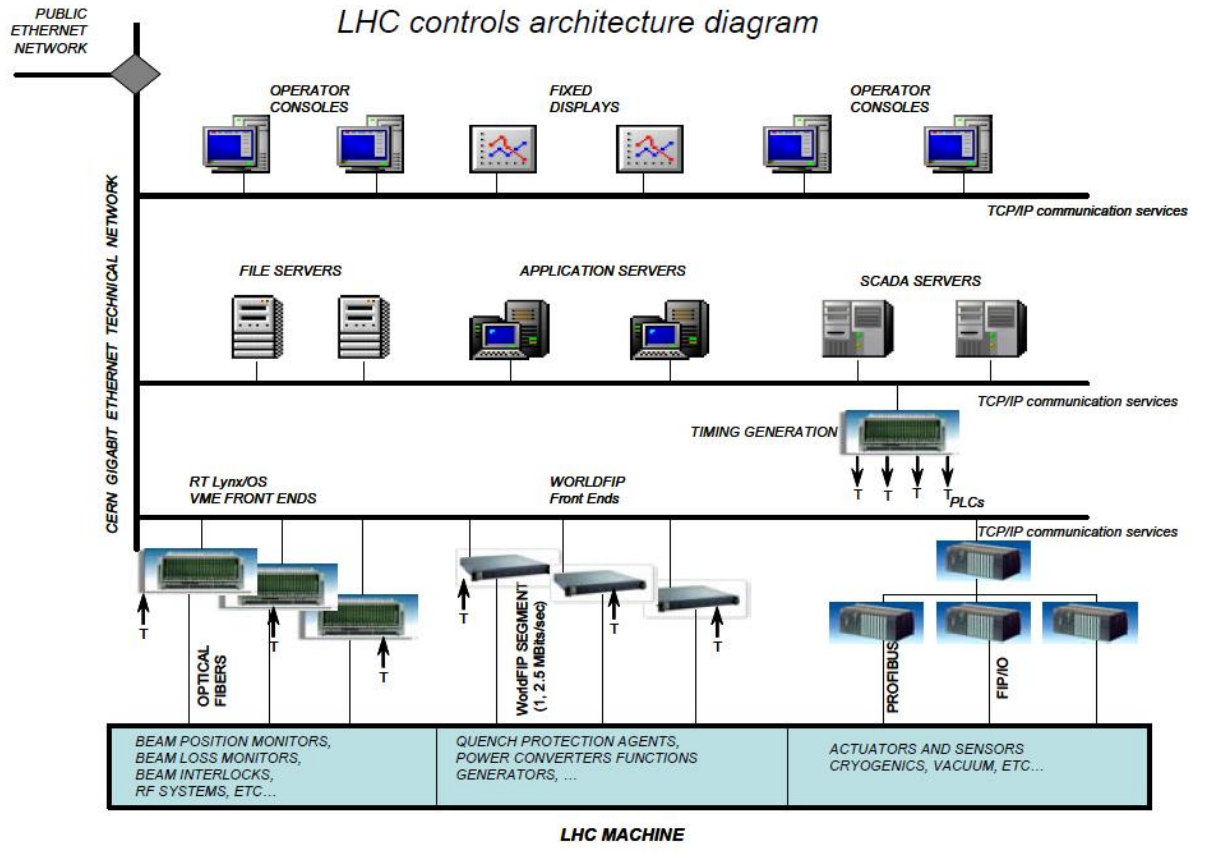
Pan-European RI

Problem statement



Research Infrastructure

Controls standard model



Various middleware solutions:

EPICS, TNE, ACOP, DOOCS, COACK, TANGO, ACS, UNICOS, JAVA+ CORBA.

Pan-European RI

Challenges

- Integration
  - Geographically separated subsystems
  - Configuration and versioning
- Complexity
  - System size and scaling (more than 10 000 signals)
  - Distributed processing
  - Availability, redundancy
- Data handling
- Fast feedback control
  - Response time, model based automation
- Reliability
  - Continuous monitoring of system state
- Configurability

Arrowhead project

Framework for collaborative automation

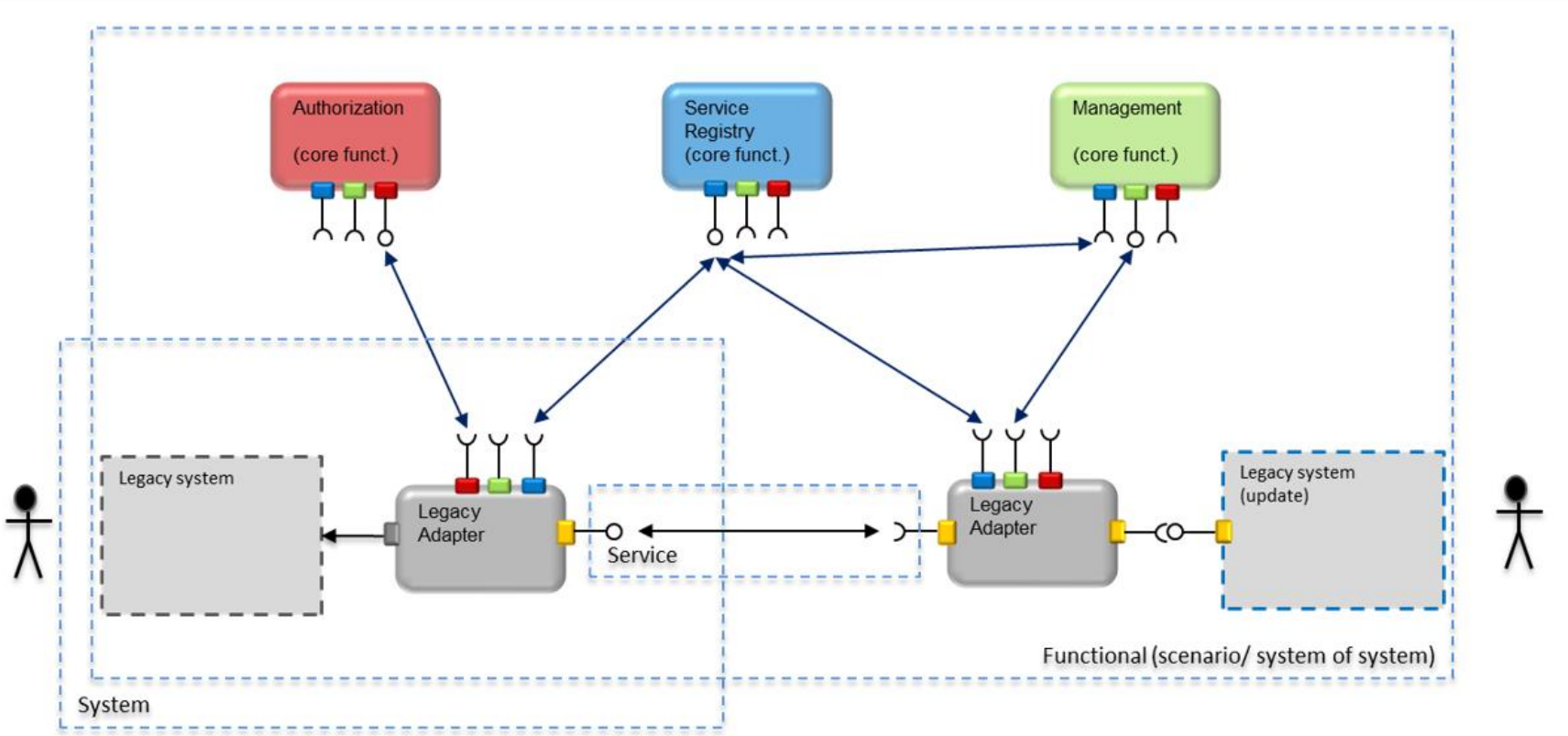
- SoA approach for distributed automation
- System of Systems concept
- Technical framework for functions and performance
- Integration with legacy systems

- Generic integration framework for **heterogeneous** systems
  - Sensors
  - PLCs
  - High speed control blocks (FPGA, DSP, HPC controllers)
  - HMI devices
  - Data warehouses and central control computers

Arrowhead framework

Conceptual overview

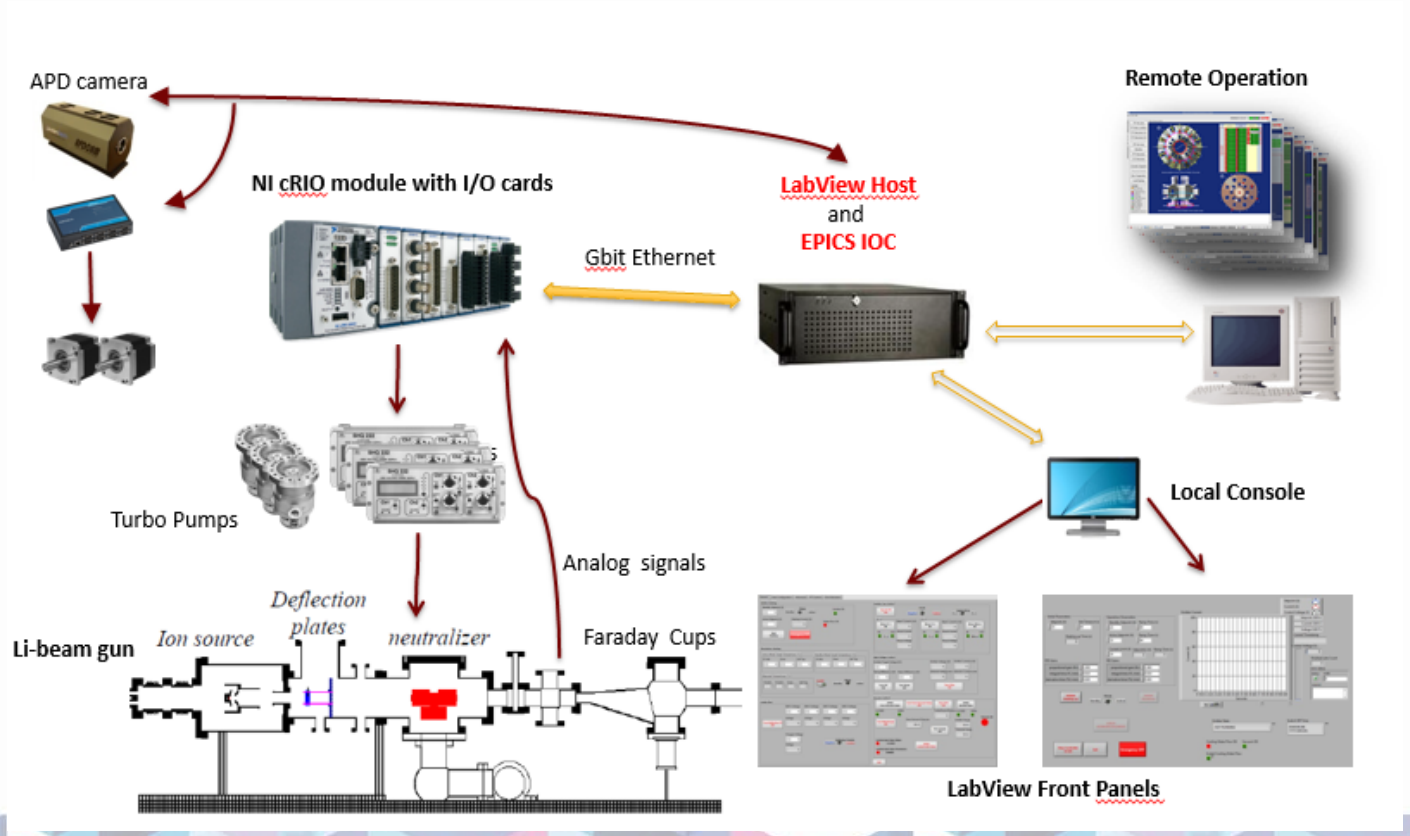
- SoA fundamentals: Lookup, Loosely coupling, Late binding
- Core services: Information Infrastructure (II), Information Assurance (IA), Systems Management (SM)



Example

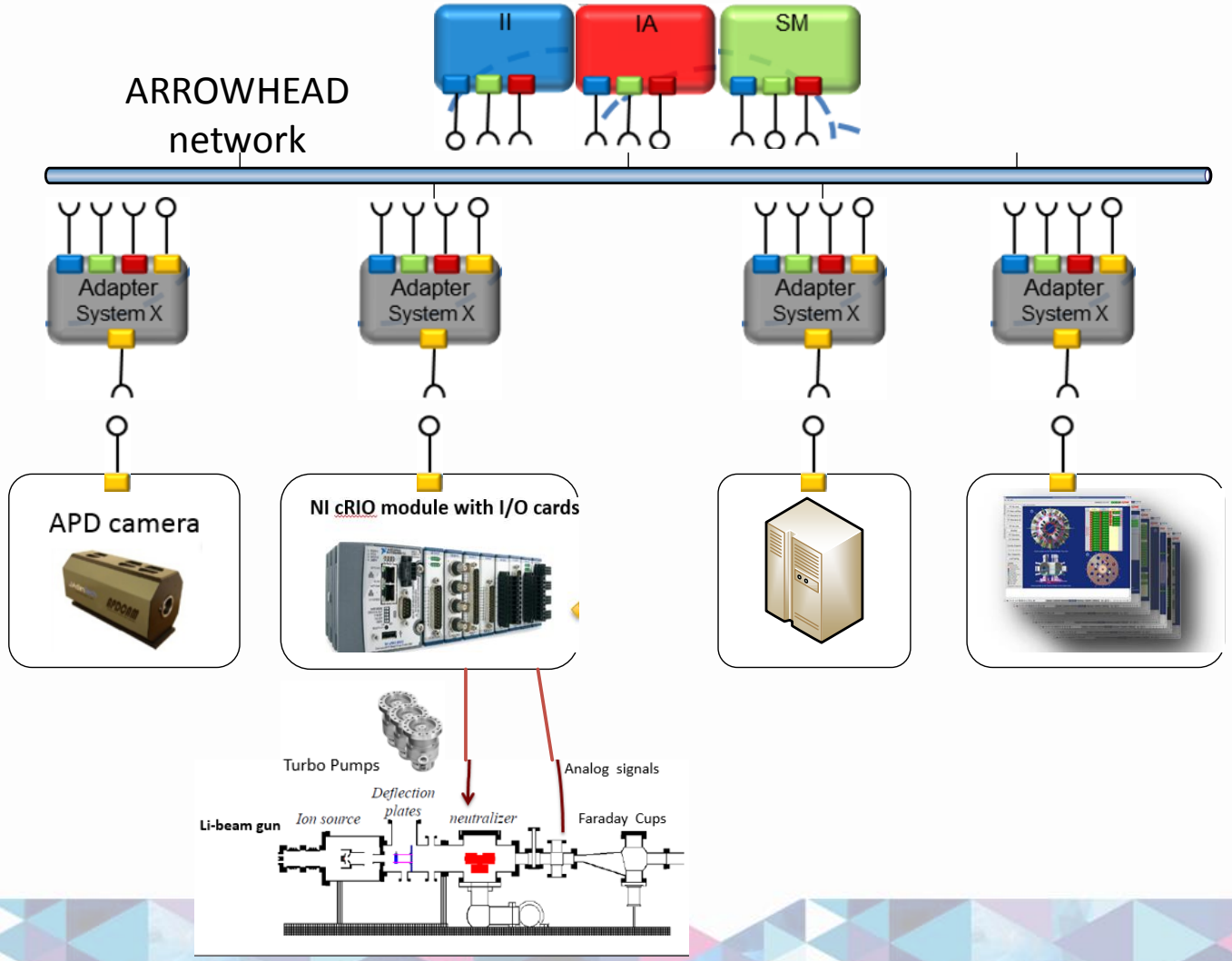
Li-Beam emission control

- Beam Emission Spectroscopy at tokamaks: KSTAR (South Korea), JET (UK), EAST (China)



Example

Li-Beam emission control as an Arrowhead system



Example

Li BES Arrowhead system

Systems used in Beam emission spectroscopy:

- Service Registry System
- Authorisation System
- Orchestration System
- MMI Service Registry System (graphical user interface application to view available Services)
- MMI Authorisation System (graphical user interface application for access control management)
- MMI Orchestration System (graphical user interface application for service composition)

Benefits of Arrowhead in RI

- Graphical modeling framework to plan and investigate systems
- High level abstraction suitable for physicists
- Simulation for experiment planning
- Seamless integration of heterogeneous components:
  - PLCs (C, logical programming)
  - Multicore control servers (C, C++, Java)
  - Fast controllers FPGAs (VHDL, Verilog)
  - Proprietary hardware (e.g. NI LabView)
- Effective and descriptive documentation

Thank you for your attention!