Elastic Adaptation of SDN/NFV Systems to Dynamic Service Demands

Pedro Martinez-Julia
Network Science and Convergence Device Technology Laboratory, Network System Research Institute
National Institute of Information and Communications Technology
`pedro@nict.go.jp`

IRTF/NFVRG, IETF 100 Meeting, Singapore

14 November 2017

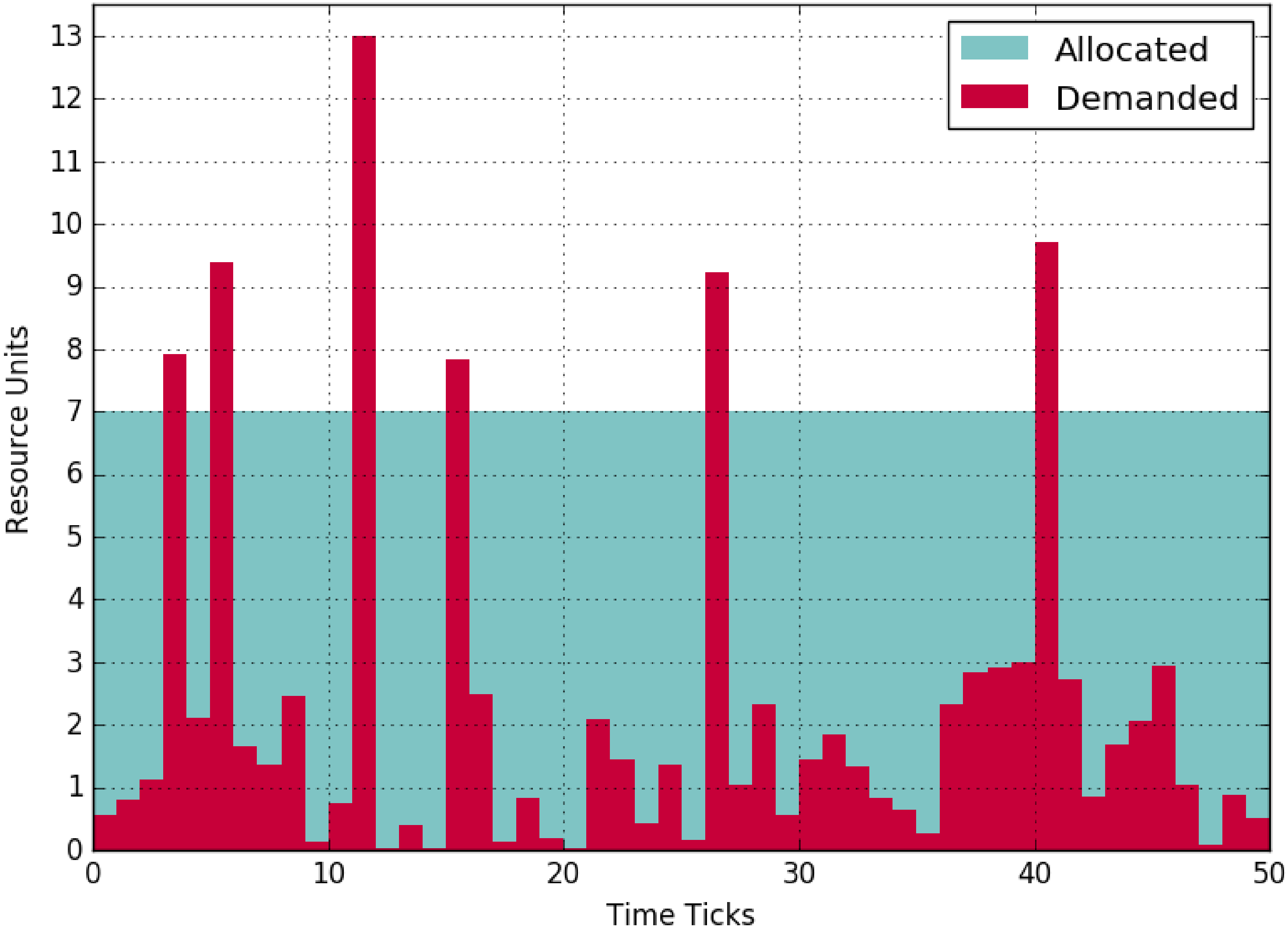
Outline

- Motivation and Research Topic
- Proposed Approach and Architecture
- Alignment With ETSI-NFV-MANO
- Conclusions & Future Work

Motivation and Research Topic (I)

Trivia:

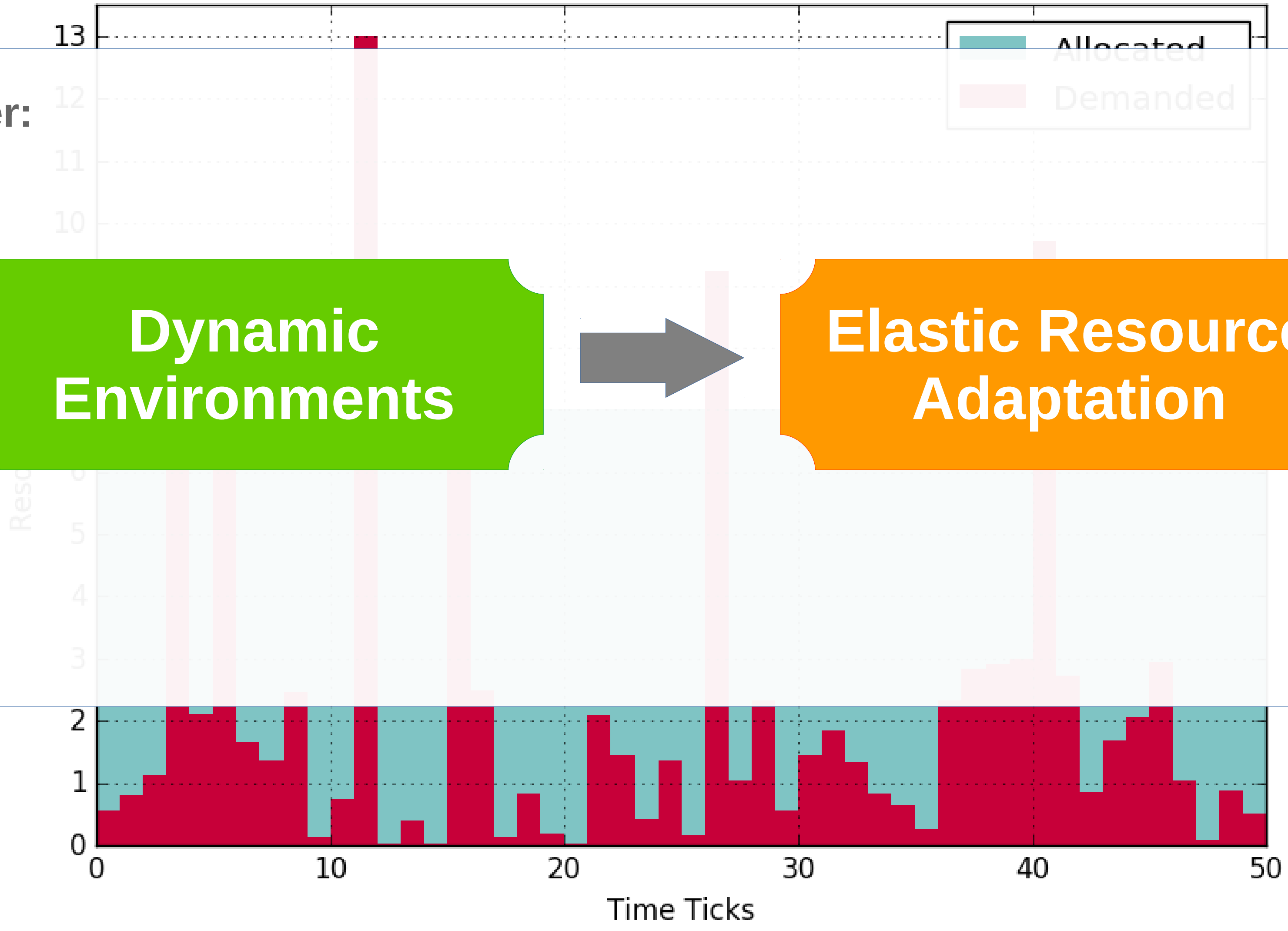
“High variation in resource demand” vs “Fixed resource allocation”.



Motivation and Research Topic (II)

Trivia:

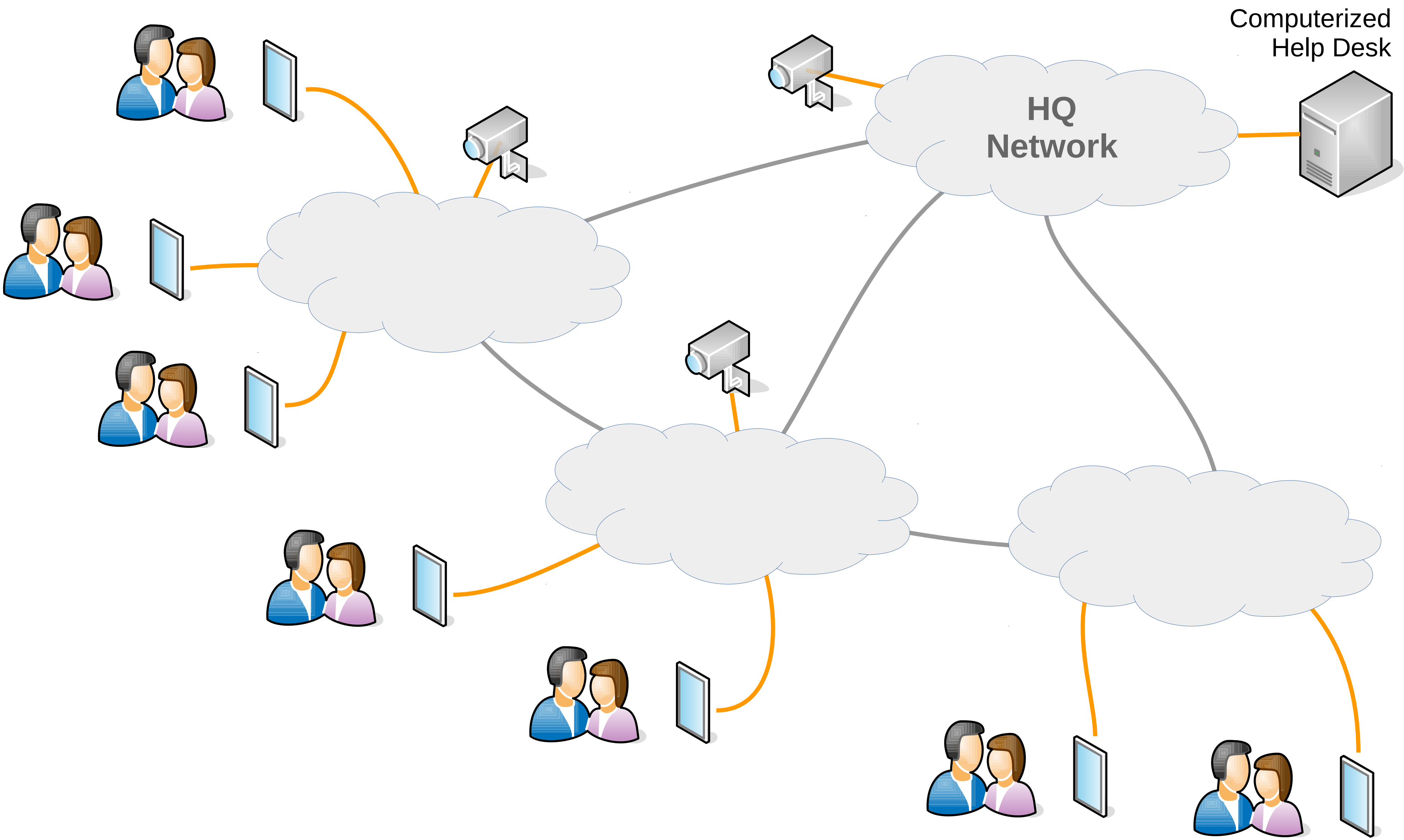
“High variation in resource demand” vs “Fixed resource allocation”.



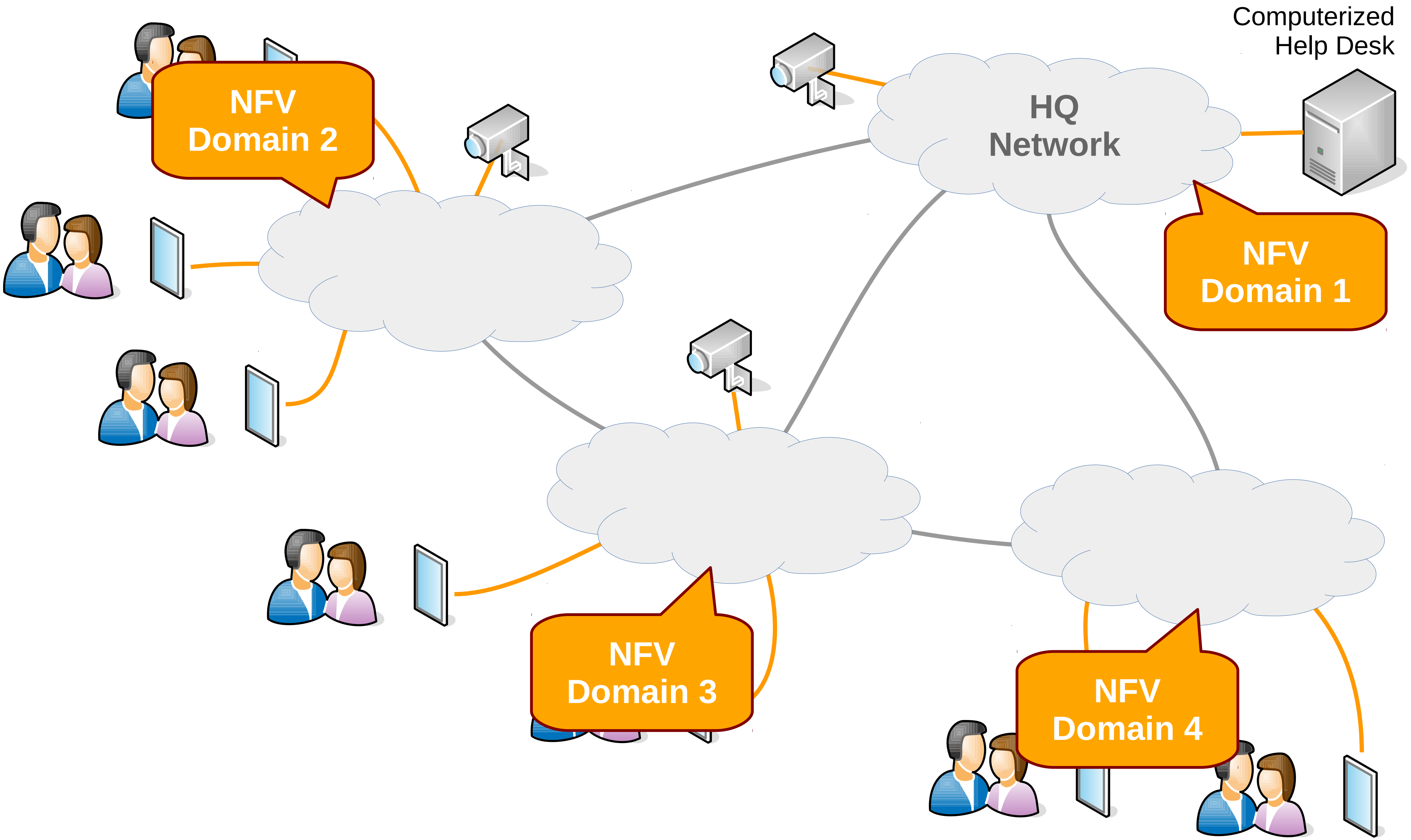
Answer:

Dynamic Environments → **Elastic Resource Adaptation**

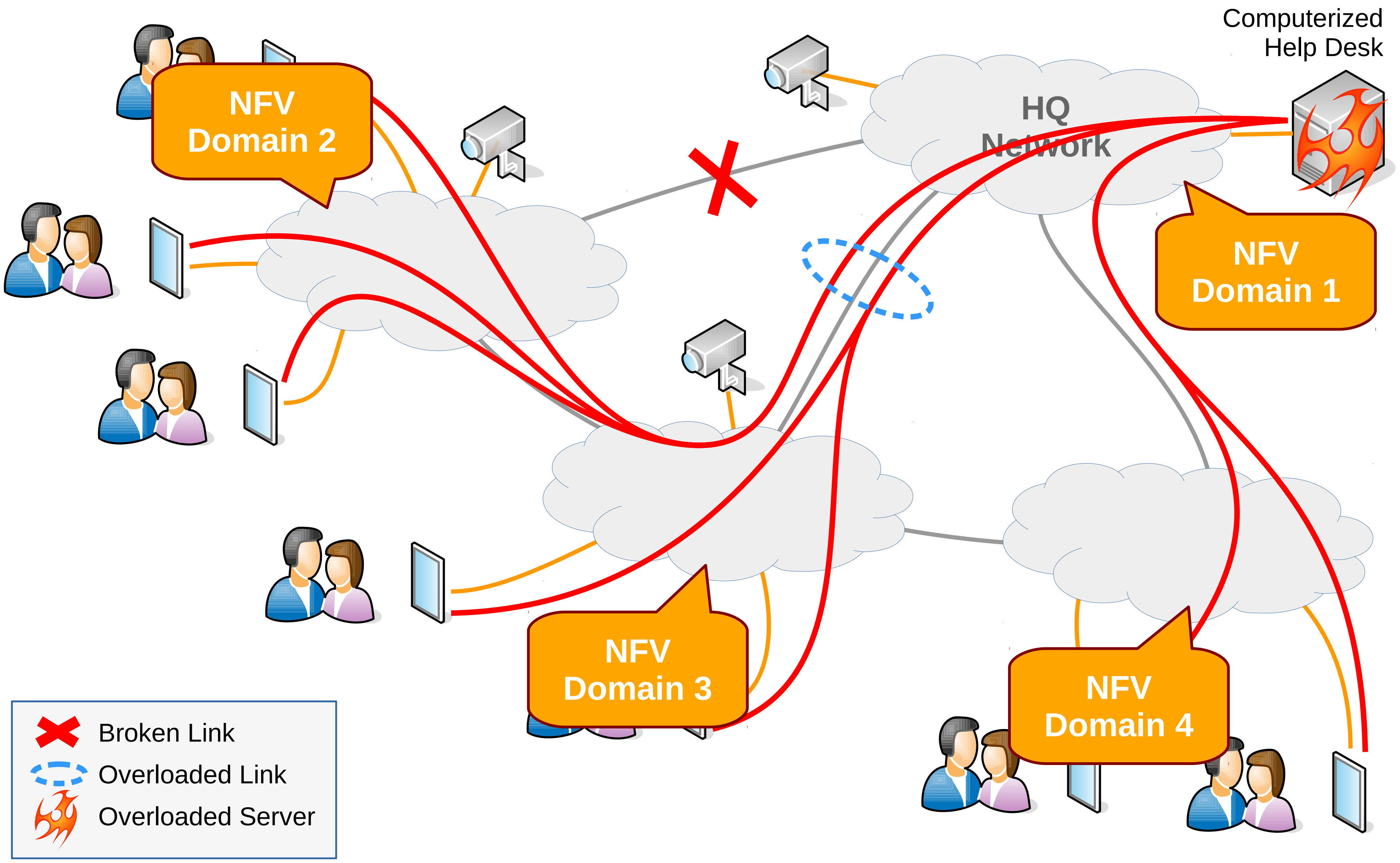
Use Case (I)


Computerized
Help Desk
HQ
Network

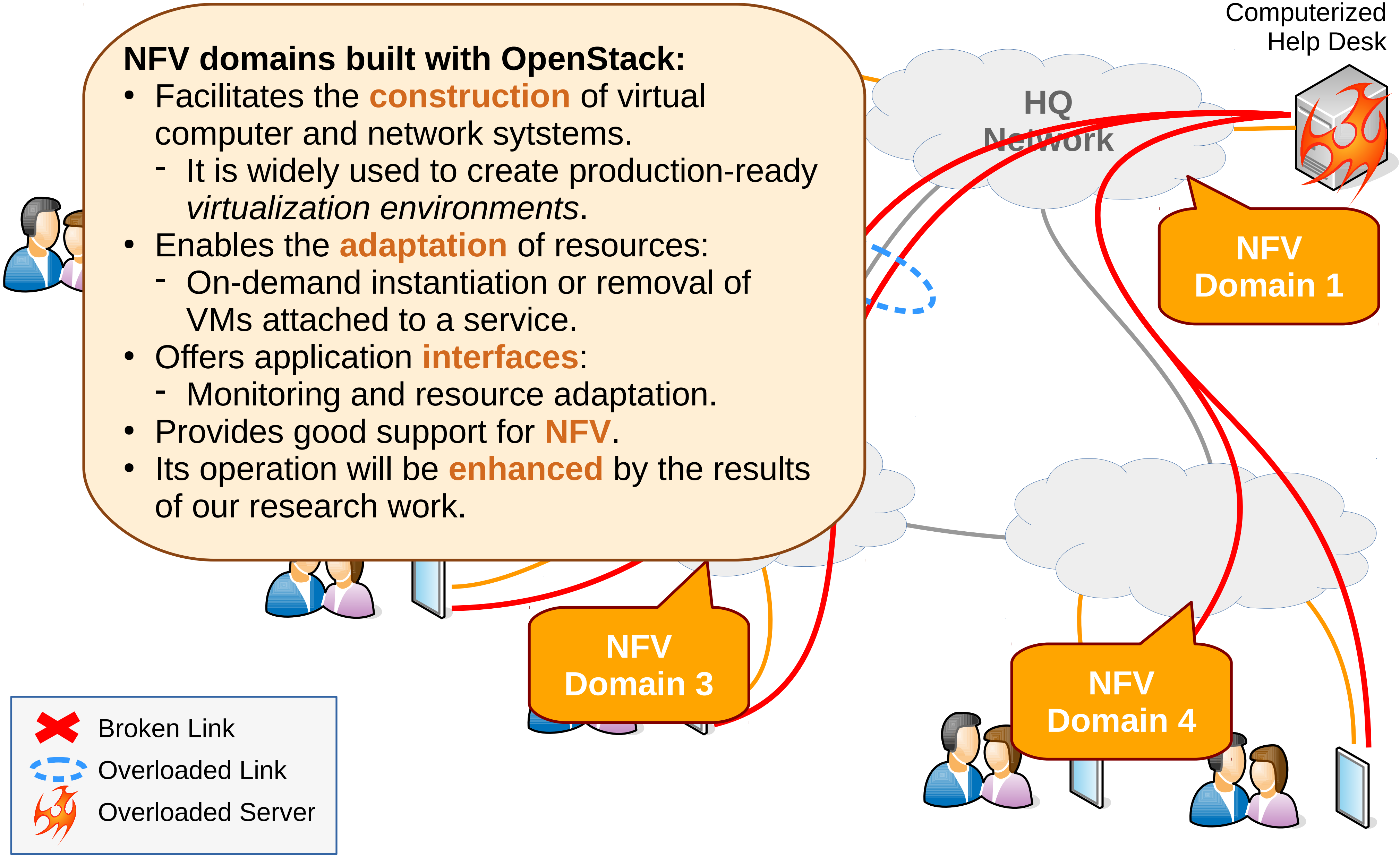
Use Case (II)


NFV
Domain 2
HQ
Network
Computerized
Help Desk
NFV
Domain 1
NFV
Domain 3
NFV
Domain 4

Use Case (III)


Computerized
Help Desk
HQ
Network
NFV
Domain 2
NFV
Domain 1
NFV
Domain 3
NFV
Domain 4
Broken Link
Overloaded Link
Overloaded Server

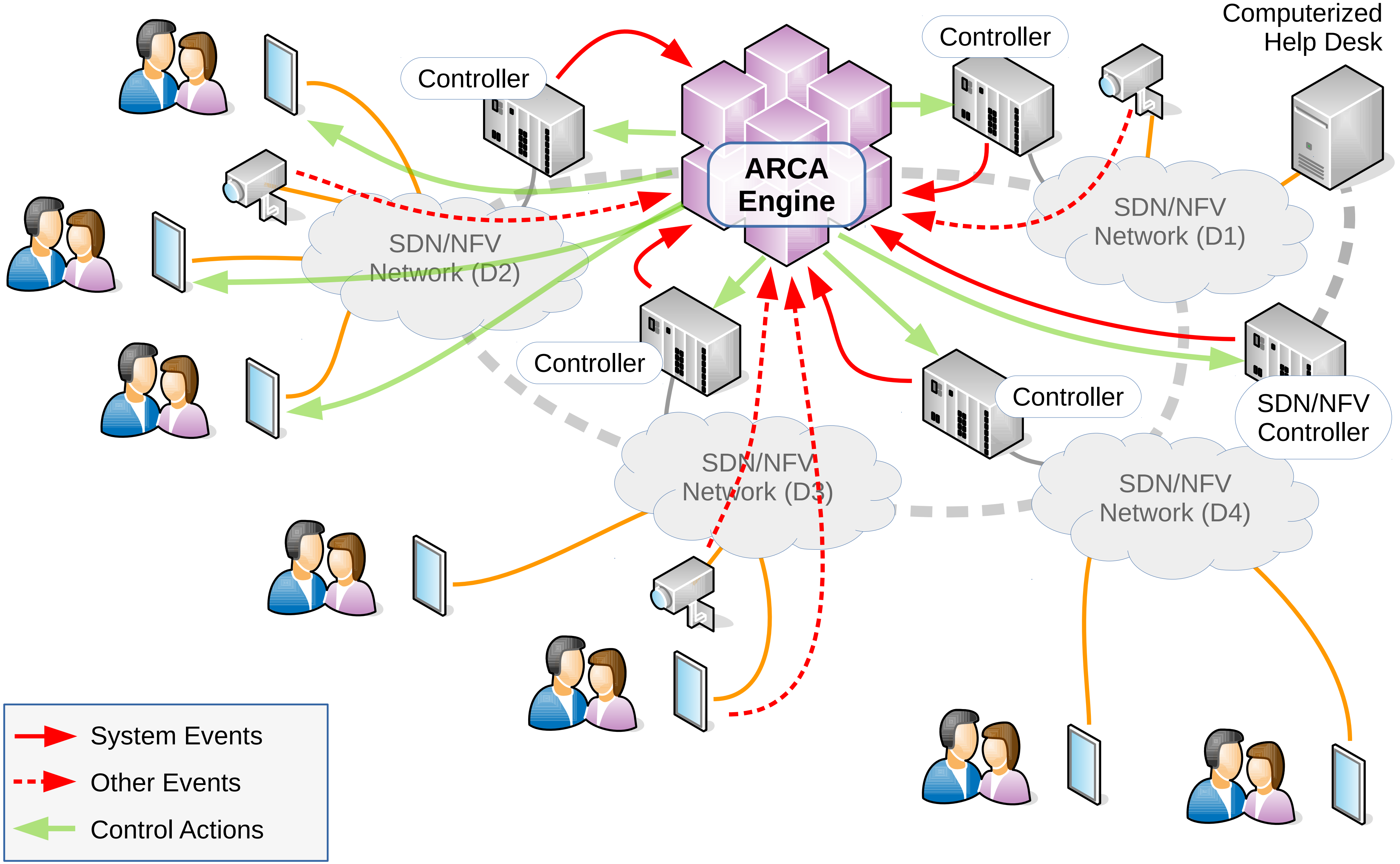
Use Case (IV)


Computerized Help Desk
HQ Network
NFV Domain 1
NFV Domain 3
NFV Domain 4
✖ Broken Link
Overloaded Link
Overloaded Server

NFV domains built with OpenStack:

- Facilitates the **construction** of virtual computer and network sytstems.
  - It is widely used to create production-ready *virtualization environments*.
- Enables the **adaptation** of resources:
  - On-demand instantiation or removal of VMs attached to a service.
- Offers application **interfaces**:
  - Monitoring and resource adaptation.
- Provides good support for **NFV**.
- Its operation will be **enhanced** by the results of our research work.

Proposed Approach (I)



Computerized
Help Desk

Controller

Controller

Controller

Controller

ARCA
Engine

SDN/NFV
Network (D1)

SDN/NFV
Network (D2)

SDN/NFV
Network (D3)

SDN/NFV
Network (D4)

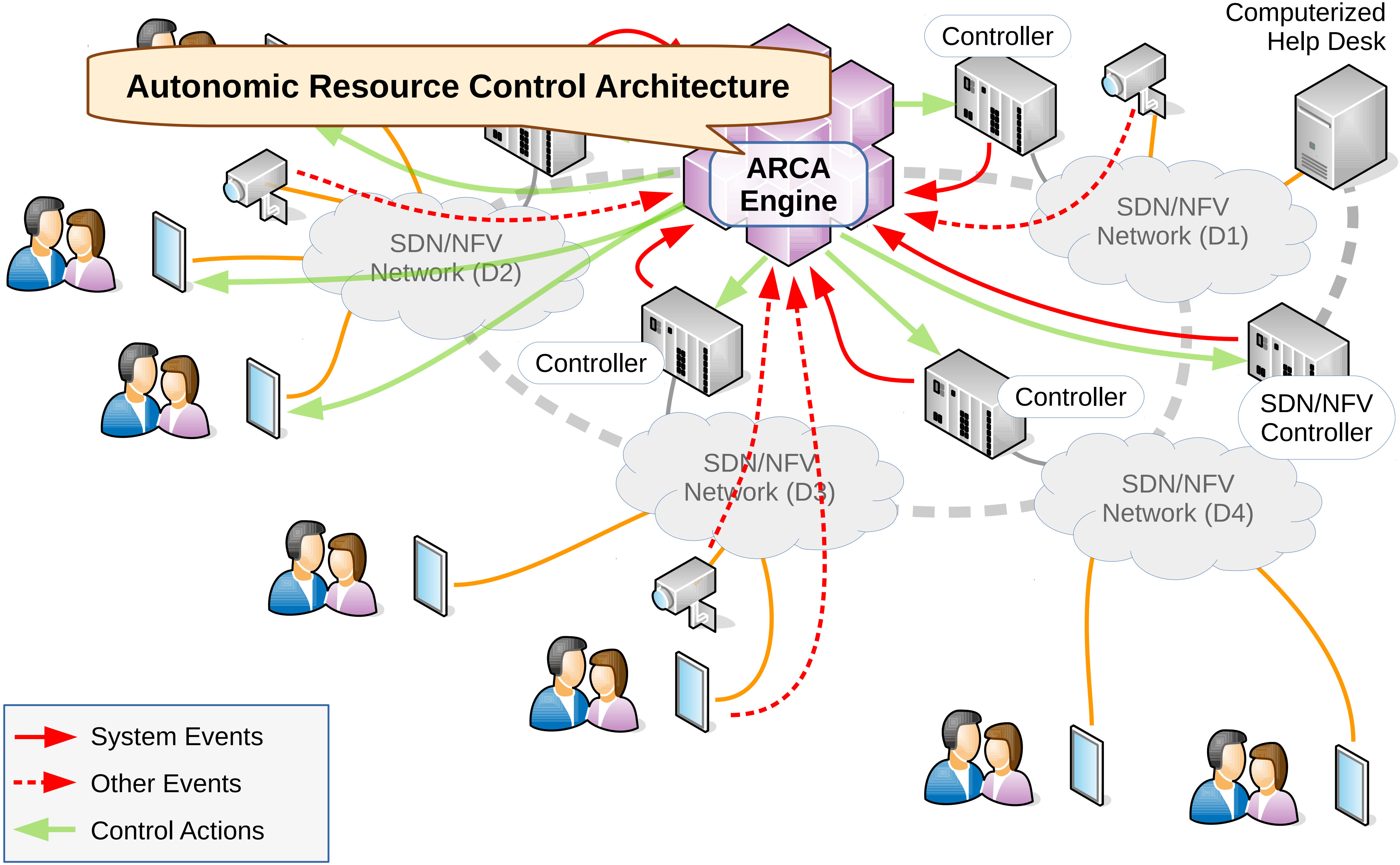
SDN/NFV
Controller

System Events

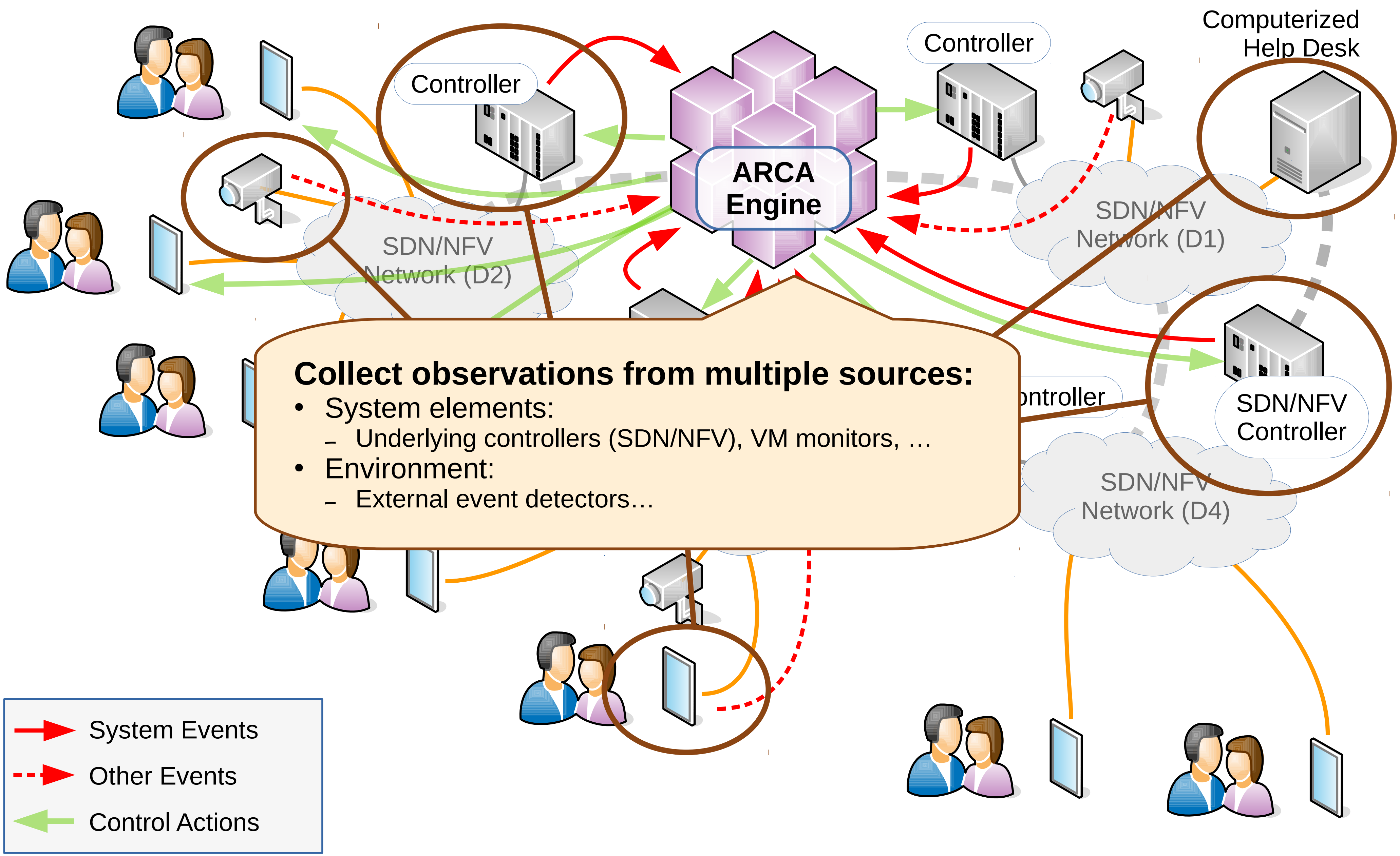
Other Events

Control Actions

Proposed Approach (II)


Autonomic Resource Control Architecture
ARCA Engine
Controller
Computerized Help Desk
SDN/NFV Network (D1)
SDN/NFV Network (D2)
Controller
Controller
SDN/NFV Controller
SDN/NFV Network (D3)
SDN/NFV Network (D4)
System Events
Other Events
Control Actions

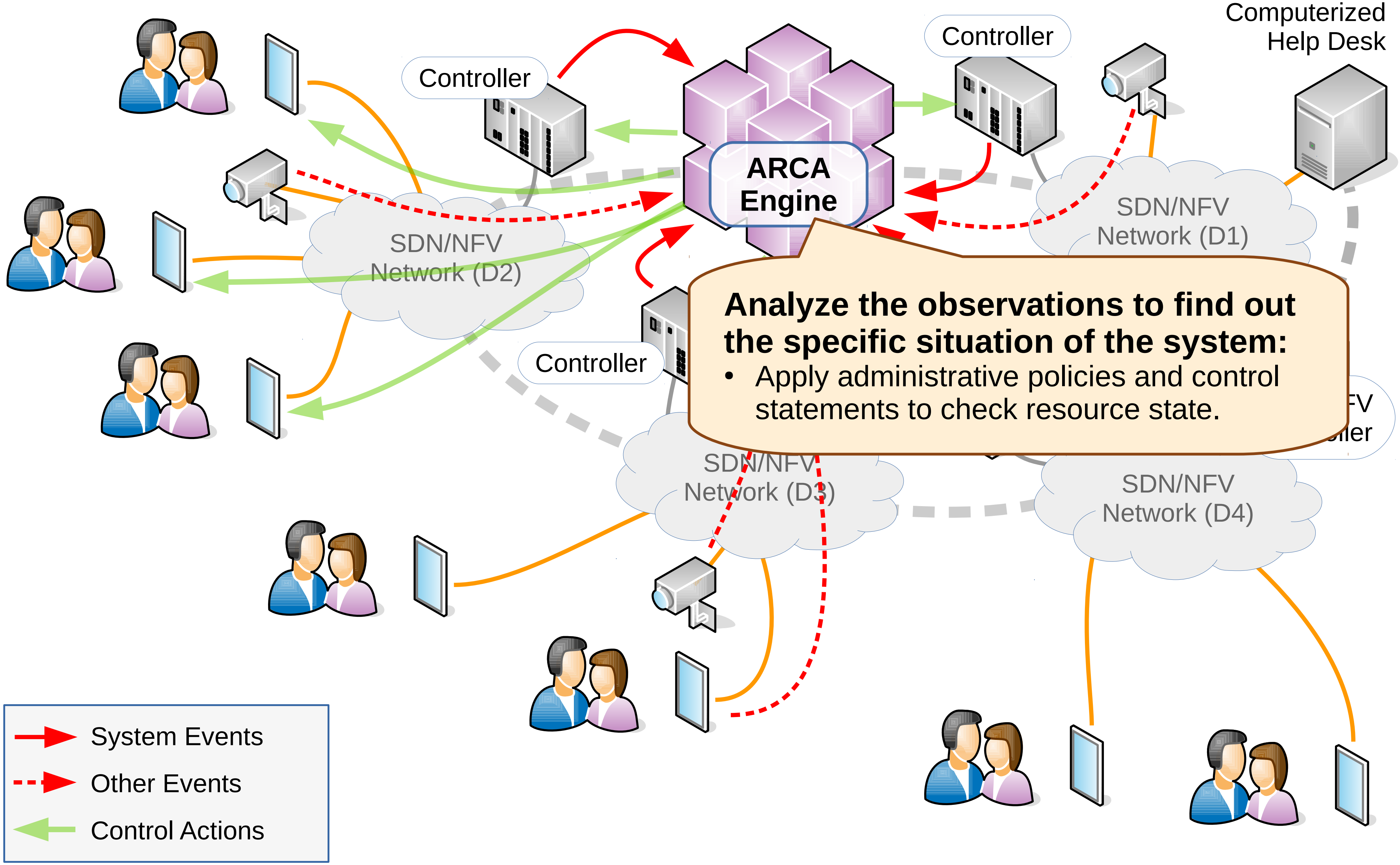
Proposed Approach (III)


Computerized Help Desk
Controller
Controller
ARCA Engine
SDN/NFV Network (D1)
SDN/NFV Network (D2)
ontroller
SDN/NFV Controller
SDN/NFV Network (D4)
System Events
Other Events
Control Actions

Collect observations from multiple sources:

- System elements:
  - Underlying controllers (SDN/NFV), VM monitors, …
- Environment:
  - External event detectors…

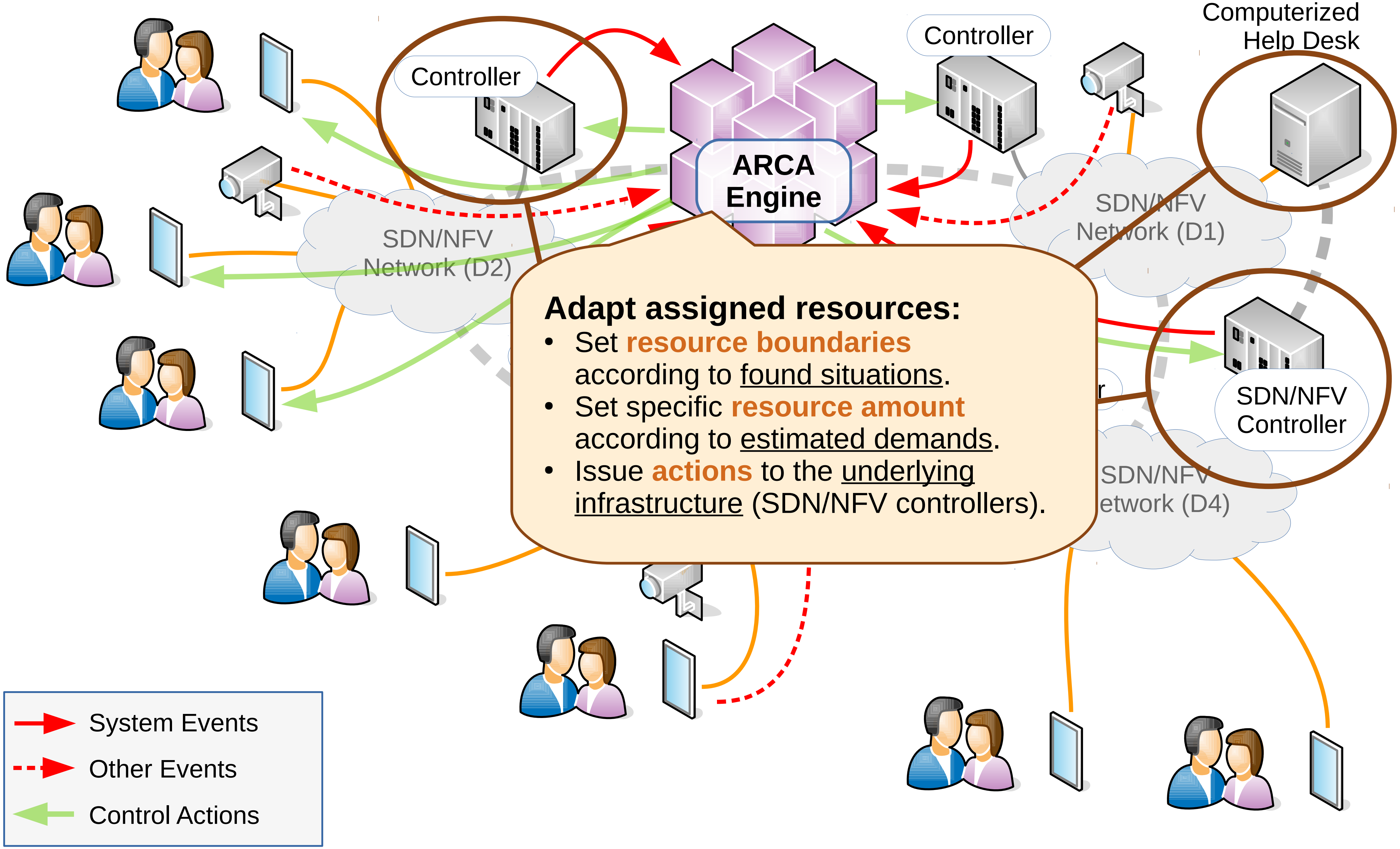
Proposed Approach (IV)


Computerized Help Desk
Controller
Controller
Controller
ARCA Engine
SDN/NFV Network (D1)
SDN/NFV Network (D2)
SDN/NFV Network (D3)
SDN/NFV Network (D4)
FV
ller
System Events
Other Events
Control Actions

Analyze the observations to find out the specific situation of the system:

- Apply administrative policies and control statements to check resource state.

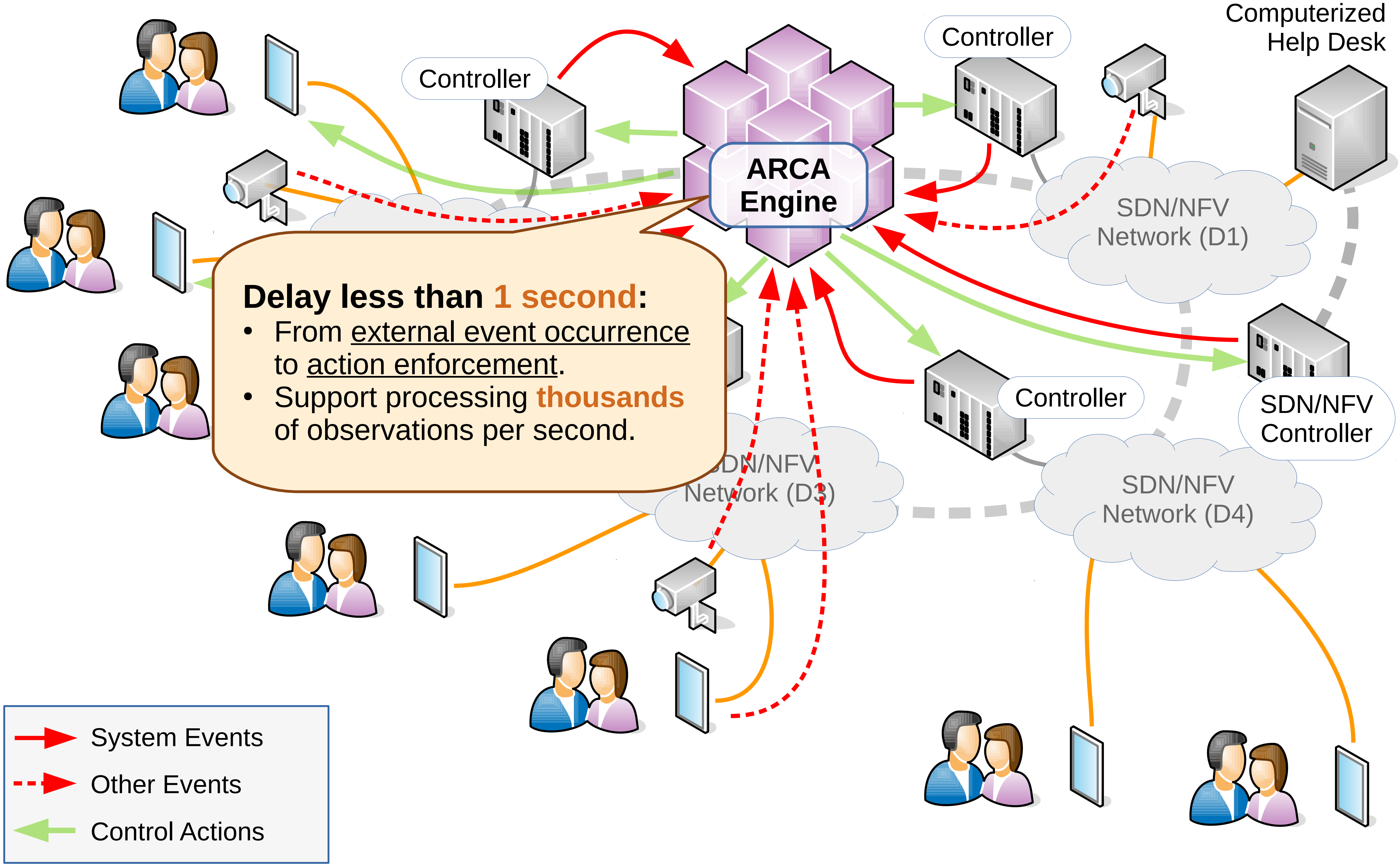
Proposed Approach (V)


Controller
Controller
Computerized Help Desk
ARCA Engine
SDN/NFV Network (D2)
SDN/NFV Network (D1)
SDN/NFV Controller
SDN/NFV etwork (D4)
System Events
Other Events
Control Actions

Adapt assigned resources:

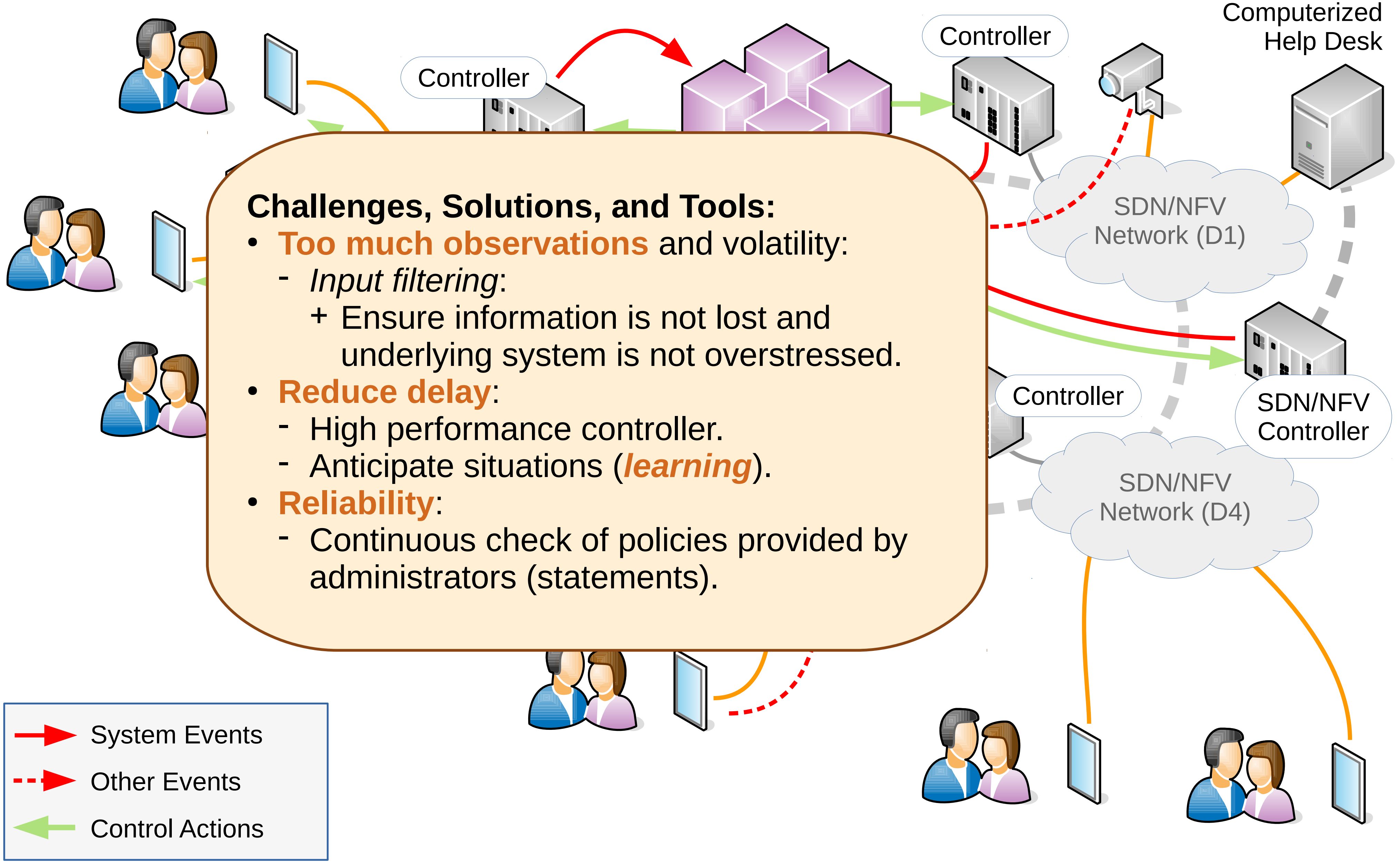
- Set **resource boundaries** according to found situations.
- Set specific **resource amount** according to estimated demands.
- Issue **actions** to the underlying infrastructure (SDN/NFV controllers).

Proposed Approach (VI)


Controller
ARCA Engine
Controller
Computerized Help Desk
SDN/NFV Network (D1)
SDN/NFV Network (D3)
Controller
SDN/NFV Controller
SDN/NFV Network (D4)
System Events
Other Events
Control Actions

Delay less than 1 second:
- From external event occurrence to action enforcement.
- Support processing **thousands** of observations per second.

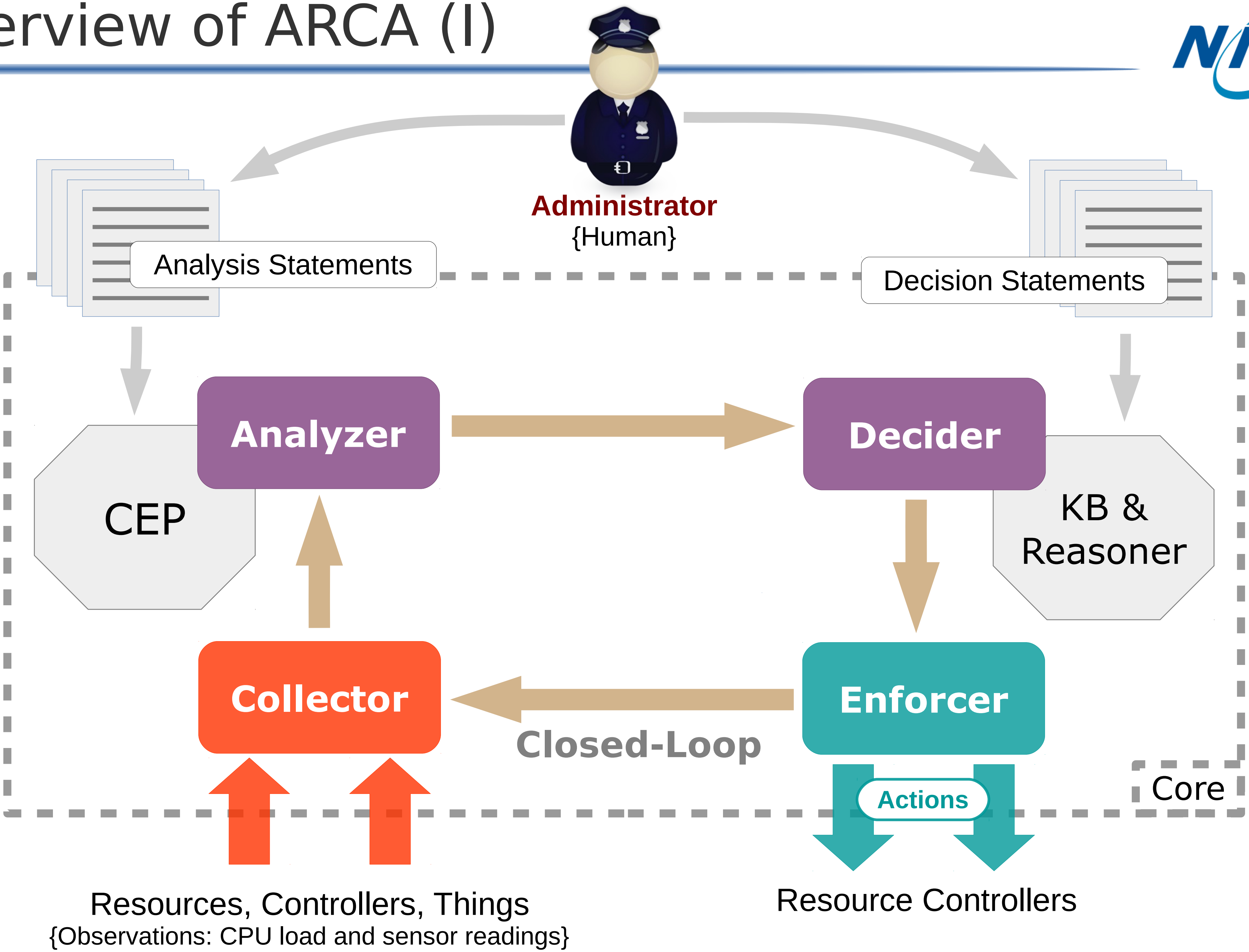
Proposed Approach (VII)


Controller
Controller
Computerized Help Desk
SDN/NFV Network (D1)
Controller
SDN/NFV Controller
SDN/NFV Network (D4)
System Events
Other Events
Control Actions

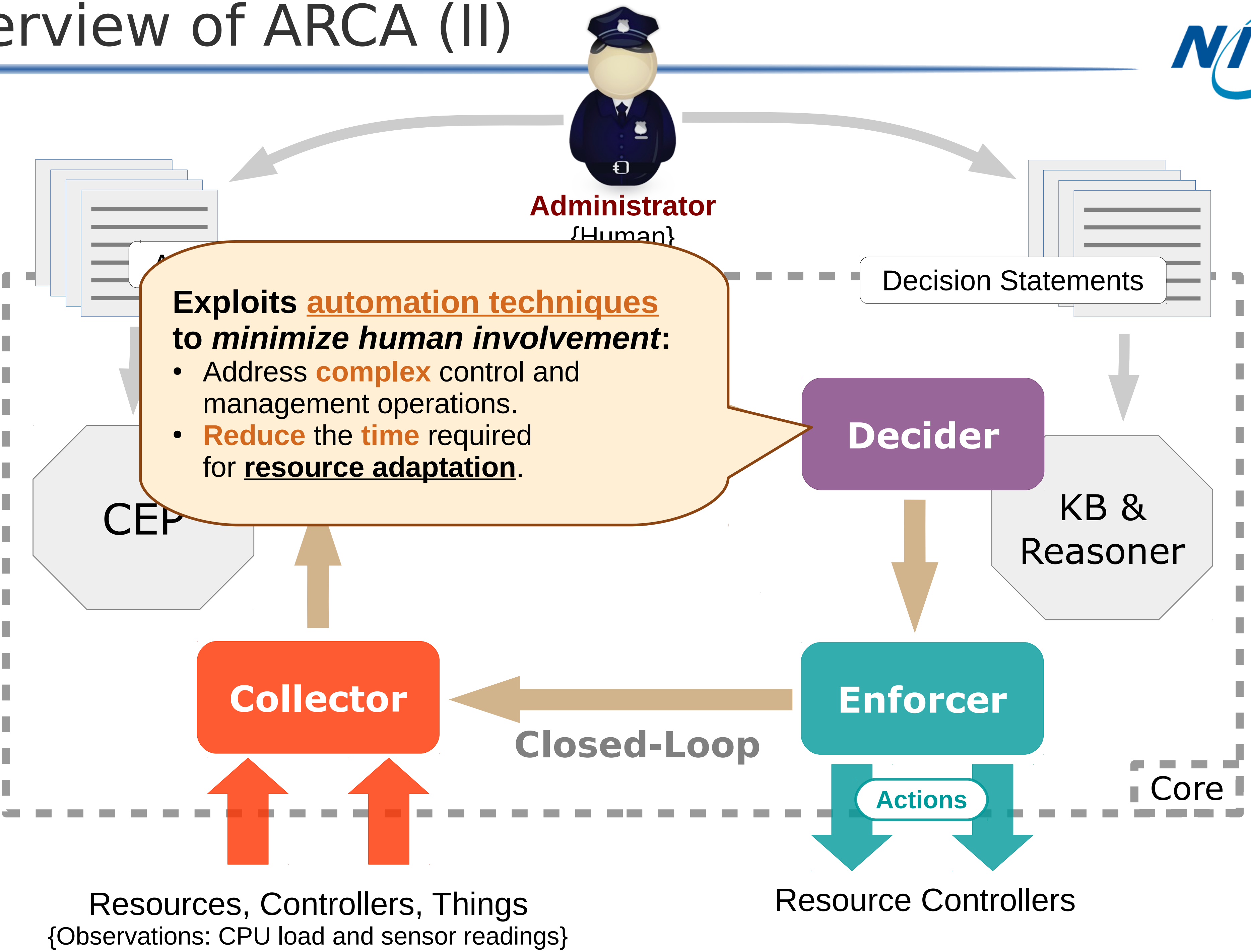
Challenges, Solutions, and Tools:

- **Too much observations** and volatility:
  - *Input filtering*:
    - + Ensure information is not lost and underlying system is not overstressed.
- **Reduce delay**:
  - High performance controller.
  - Anticipate situations (***learning***).
- **Reliability**:
  - Continuous check of policies provided by administrators (statements).

Overview of ARCA (I)


Administrator
{Human}
Analysis Statements
Decision Statements
Analyzer
CEP
Decider
KB &
Reasoner
Collector
Enforcer
Closed-Loop
Actions
Core
Resources, Controllers, Things
{Observations: CPU load and sensor readings}
Resource Controllers

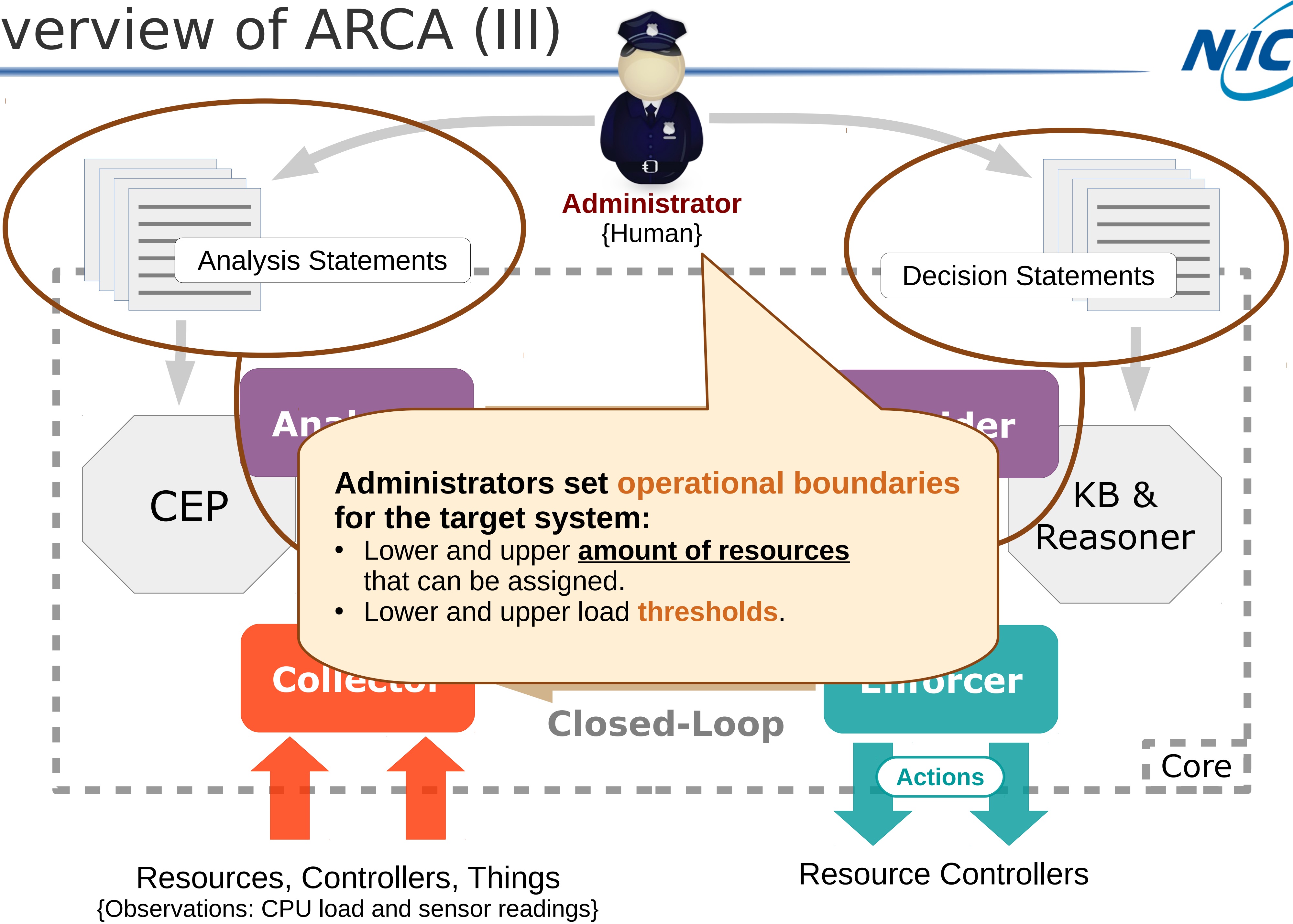
Overview of ARCA (II)


Administrator
{Human}
Decision Statements
CEP
Decider
KB & Reasoner
Collector
Closed-Loop
Enforcer
Actions
Core
Resources, Controllers, Things
{Observations: CPU load and sensor readings}
Resource Controllers

Exploits automation techniques to *minimize human involvement*:

- Address **complex** control and management operations.
- **Reduce** the **time** required for **resource adaptation**.

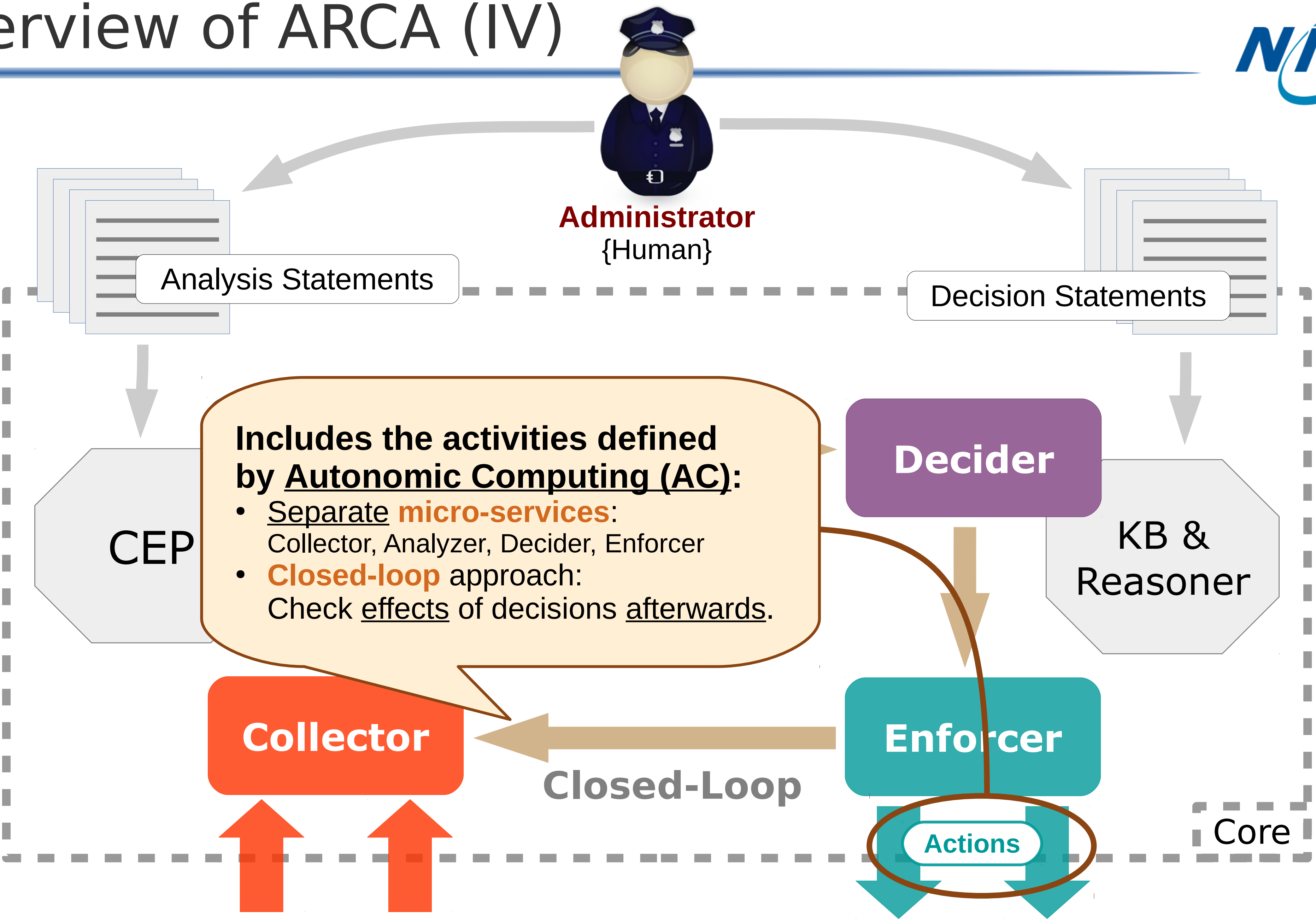
Overview of ARCA (III)


Administrator
{Human}
Analysis Statements
Decision Statements
CEP
Ana
ider
KB &
Reasoner
Collector
Enforcer
Closed-Loop
Actions
Core
Resources, Controllers, Things
{Observations: CPU load and sensor readings}
Resource Controllers

Administrators set operational boundaries for the target system:

- Lower and upper **amount of resources** that can be assigned.
- Lower and upper load **thresholds**.

Overview of ARCA (IV)


Administrator
{Human}
Analysis Statements
Decision Statements
CEP
Decider
KB & Reasoner
Collector
Enforcer
Closed-Loop
Actions
Core

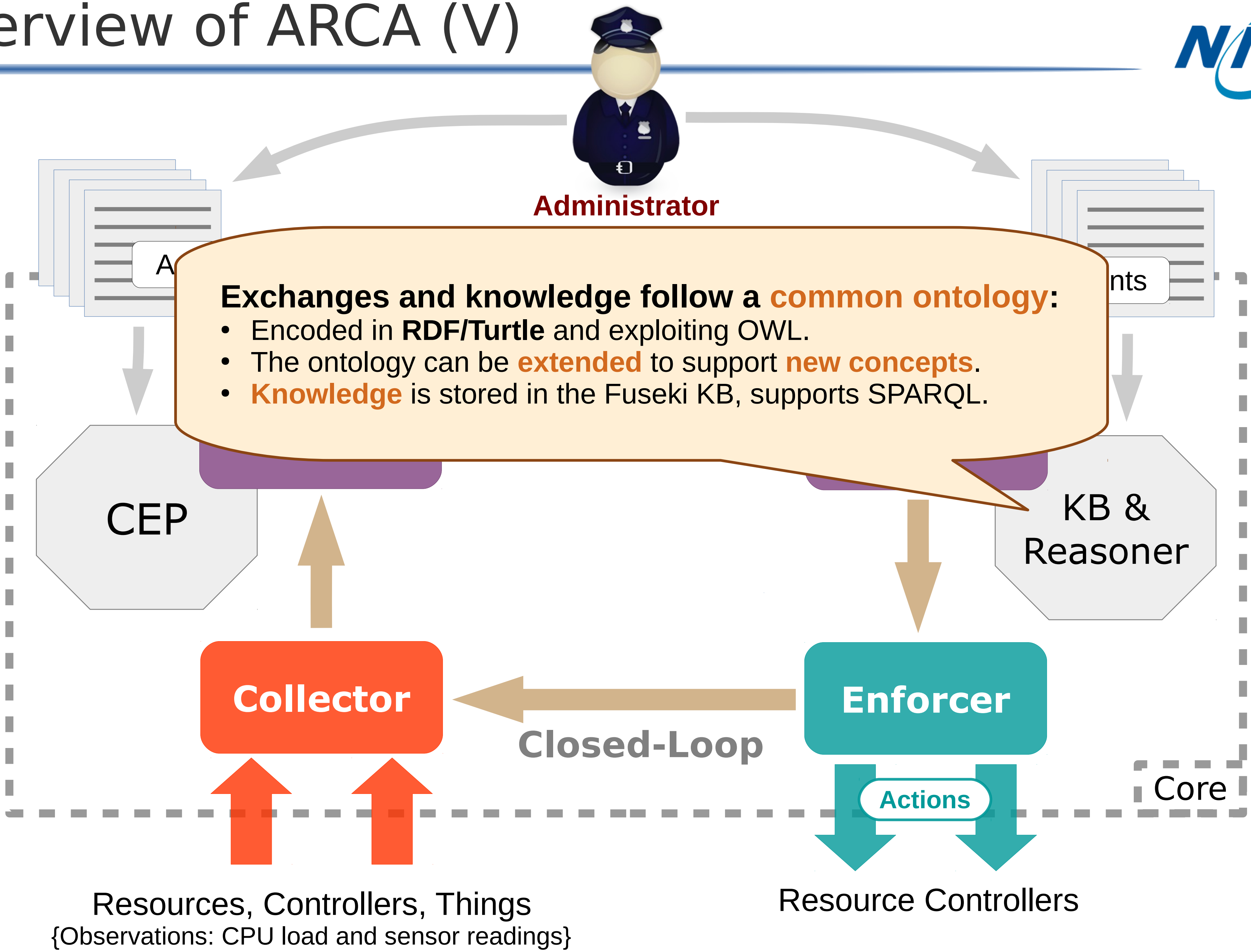
Includes the activities defined by Autonomic Computing (AC):

- Separate **micro-services**:
  Collector, Analyzer, Decider, Enforcer
- **Closed-loop** approach:
  Check effects of decisions afterwards.

Resources, Controllers, Things
{Observations: CPU load and sensor readings}

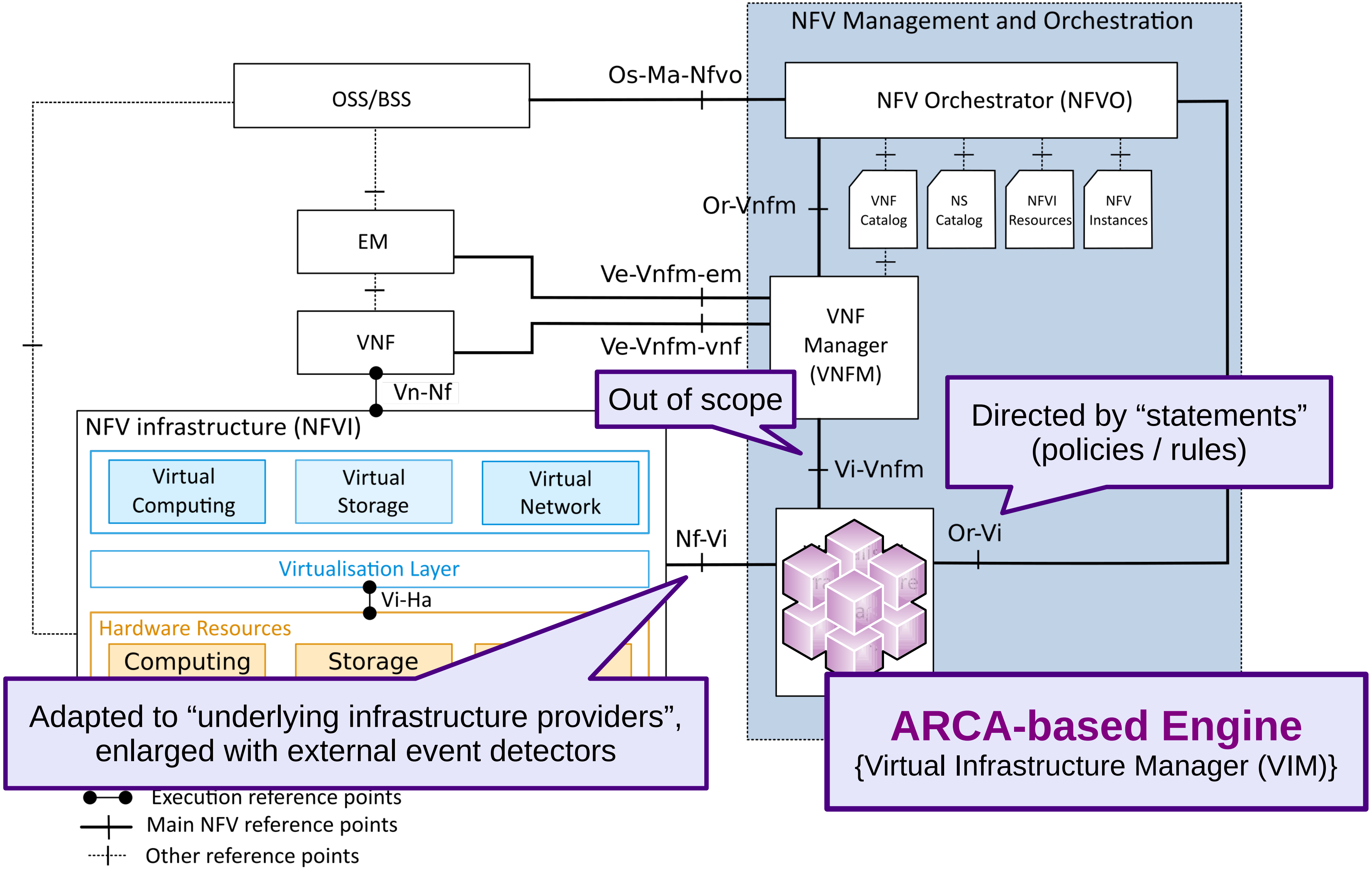
Resource Controllers

Overview of ARCA (V)


Administrator
A
nts
CEP
KB &
Reasoner
Collector
Enforcer
Closed-Loop
Actions
Core
Resources, Controllers, Things
{Observations: CPU load and sensor readings}
Resource Controllers

Exchanges and knowledge follow a common ontology:
- Encoded in **RDF/Turtle** and exploiting OWL.
- The ontology can be **extended** to support **new concepts**.
- **Knowledge** is stored in the Fuseki KB, supports SPARQL.

Alignment With ETSI-NFV-MANO (I)


NFV Management and Orchestration
OSS/BSS
Os-Ma-Nfvo
NFV Orchestrator (NFVO)
Or-Vnfm
VNF Catalog
NS Catalog
NFVI Resources
NFV Instances
EM
Ve-Vnfm-em
VNF
Ve-Vnfm-vnf
VNF Manager (VNFM)
Vn-Nf
NFV infrastructure (NFVI)
Virtual Computing
Virtual Storage
Virtual Network
Vi-Vnfm
Nf-Vi
Or-Vi
Virtualisation Layer
Vi-Ha
Hardware Resources
Computing
Storage
Execution reference points
Main NFV reference points
Other reference points

Out of scope

Directed by “statements” (policies / rules)

Adapted to “underlying infrastructure providers”, enlarged with external event detectors

ARCA-based Engine
{Virtual Infrastructure Manager (VIM)}

Alignment With ETSI-NFV-MANO (II)

- ARCA plays the role of the Virtualized Infrastructure Manager (**VIM**):
  - Provides autonomic capabilities to:
    - Discharge responsibilities from VNFM and NFVO.
    - Improve the scalability and resiliency of the system in case of disconnection from the orchestrator.
  - Is focused to accomplish requirements of Virtual Network Operators (VNOs).
- The **Nf-Vi** interface (IFA004, IFA019) in ARCA has been:
  - Bound to available underlying and overlying interfaces:
    - Ceilometer/Gnocchi provided by OpenStack.
  - Extended to enable interactions with exernal elements:
    - Physical / environmental event (incident) detectors.
    - Big Data: analyzers, data sources, etc.
- The **Or-Vi** interface (IFA005) is provided by the basic specification of control/management targets:
  - Its main communication artifact is the specification of control statements:
    - Represent the rules and policies that ARCA must enforce.
    - Will be provided by system administrators and/or external orchestrators.
  - ARCA will enforce such statements in response to changes in the environment and/or user requirements:
    - Requirements are communicated with additional statements.
- The **Vi-Vnfm** interface (IFA006) is currently out of the scope of ARCA.

Conclusions & Future Work

- Designed **ARCA**:
  - To provide functions of the Virtual Infrastructure Manager (VIM) of NFV-MANO.
  - Extended VIM interfaces to meet real requirements of the real world:
    - Emergency scenarios (!)
  - Achieved good perfomance within an OpenStack-based deployment:
    - Detailed **overlying** and **underlying** infrastructures.
    - Reproduction of production-like environments to ensure transferable research results.
- SDN/NFV and OpenStack stakeholders will benefit from ARCA features:
  - **Efficient** use of **resources**:
    - Further reduce CAPEX and OPEX:
  - Benefit to both infrastructure providers and consumers.
- Next steps:
  - Keep **reducing** ARCA **response time**.
  - Increase complexity of the validation scenario:
    - Mix clients and servants in the same domains.
  - Align **ARCA**-based VNC to **additional equirements** from **NFV**/**SDN**.

Thanks for Your Attention

Q & A

– EOF –