Exposing the Features in IP version Six protocols that can be exploited/extended for the purposes of designing/building Autonomic Networks and Services

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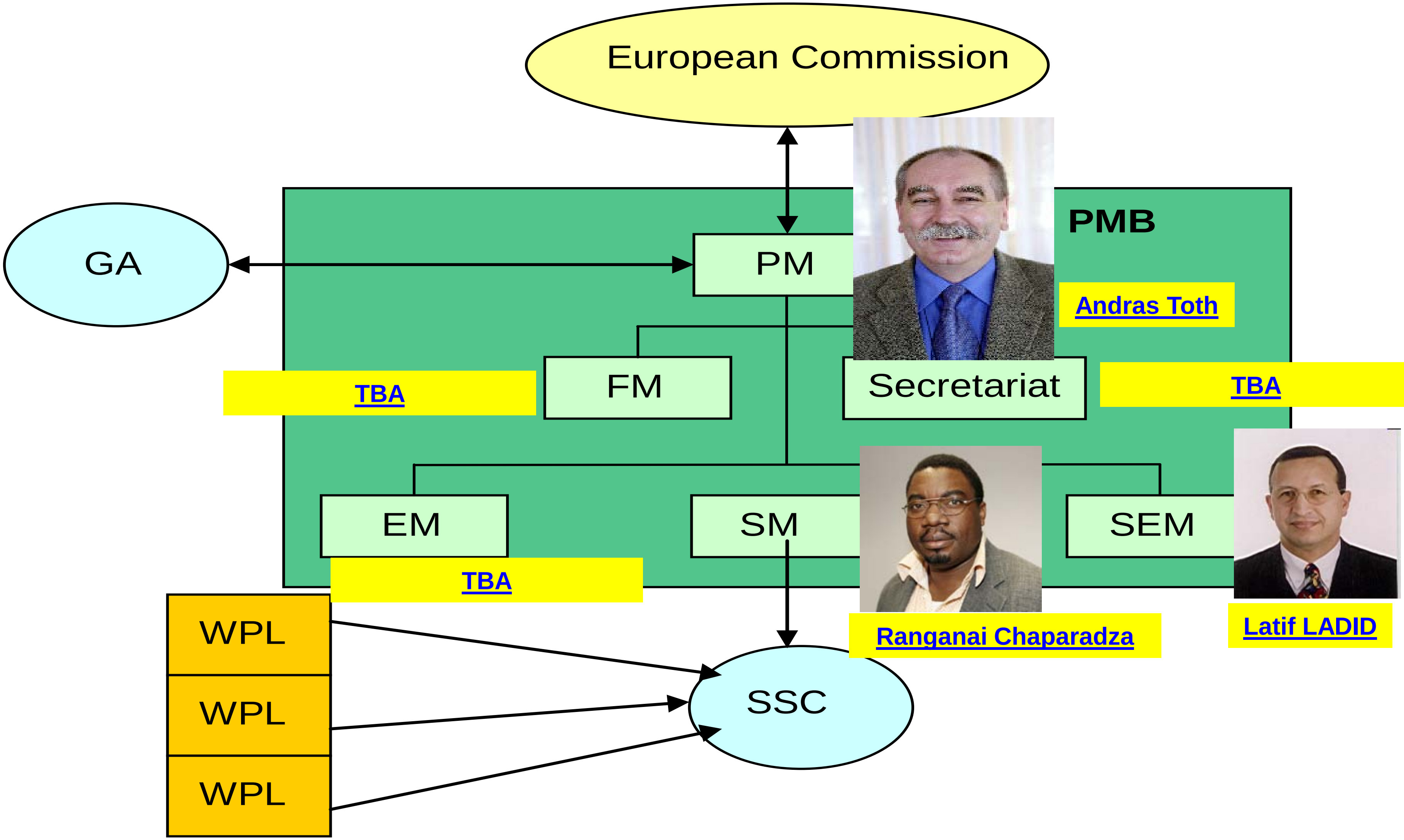
Management Structure



Why do we need EFIPSANS

- Background
  - IPv6 offers a lot of rich communication features and extensible communication possibilities beyond what is available in IPv4. To mention a few: *auto-configuration, neighbor discovery, dynamic network re-numbering, improved routing mechanisms, improved QoS (Quality of Service) handling, improved transport efficiency, improved security and flexible protocol extensions etc*.
  - The research area of Autonomic Networking (Self-Managing Networks) is becoming hot and hot across the industry and academia.
  - *The Speed of Migration (Transitioning) to IPv6* hinges on having a *richer insight* ***(currently lacking!!)*** into the benefits of IPv6 and the potential doors to new communication paradigms IPv6 protocols can open. EFIPSANS envisions that the extensibility of the IPv6 protocol framework opens the door to engineering autononomicity (self-managing properties) in systems, services and networks.
- The EFIPSANS Innovation and the Research Strategy
  - Explore and bring IPv6 into other strongly promising avenues and stir up hot research issues around the hidden potential benefits of migration, given that EFIPSANS seeks to produce a *rich insight* into the role of IPv6 and its extensions in engineering "autonomicity" in networks, systems and services.
  - Produce Extensions to IPv6 (IPv6++) and the corresponding network architectures required for engineering autonomicity in systems and networks.
- The EFIPSANS Research Outcome
  - A set of Specifications, Technical Reports and/or new Complementary Draft RFCs consisting of: *the identified exploitable IPv6 features*; *propositions for extensions to the IPv6 protocols*; *concrete feature-combination scenarios for engineering autonomicity,* and *Experimental Results*. The new Extensions to IPv6 features and network architectures imply New Complementary RFCs, which imply IPv6++ (IPv6 with Autonomic Flavours).
- Potential Strong Impact on Industry&Global Market related to IPv6 Evolution[Benefits and Who benefits]
  - The Specifications, Technical Reports and new complementary RFCs will give a *richer documented insight* into the benefits of migrating to IPv6. For manufacturers, the specifications, reports and new complementary RFCs give an opportunity to implement novel extensions to IPv6 protocols in order to offer extended features in their products.
  - For network providers, service providers, researchers and other potential users of IPv6, the Specifications, Technical Reports new complementary RFCs give a good picture on how to view IPv6 and extended features as a platform for designing/building autonomic networks and services and, this also gives them a chance to think and contribute innovative ideas on the use of IPv6 protocols. Essentially, this will also help in *closing the gap between IPv6 and autonomic networking*.

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Multi-stakeholders will benefit

Strategic Standards Bodies Support

GRID FORUM

2005

3G mandates IPv6

4G mandates IPv6

ITS mandates IPv6

Strategic Advocacy Bodies Support

UN Fosters IPv6

IGF Fosters IPv6
Malta Prep Feb 06

WSIS Fosters IPv6

IPv6 TF Around The World

Leadership Worldwide

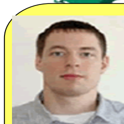
Phase 1 : 246 products
Phase 2 : 60 products
(as of Sep 1, 2006)

Dr. Hiroshi Esaki

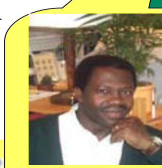
15% — 35 / 12

3% — 8 / 2

82% — 203 / 46



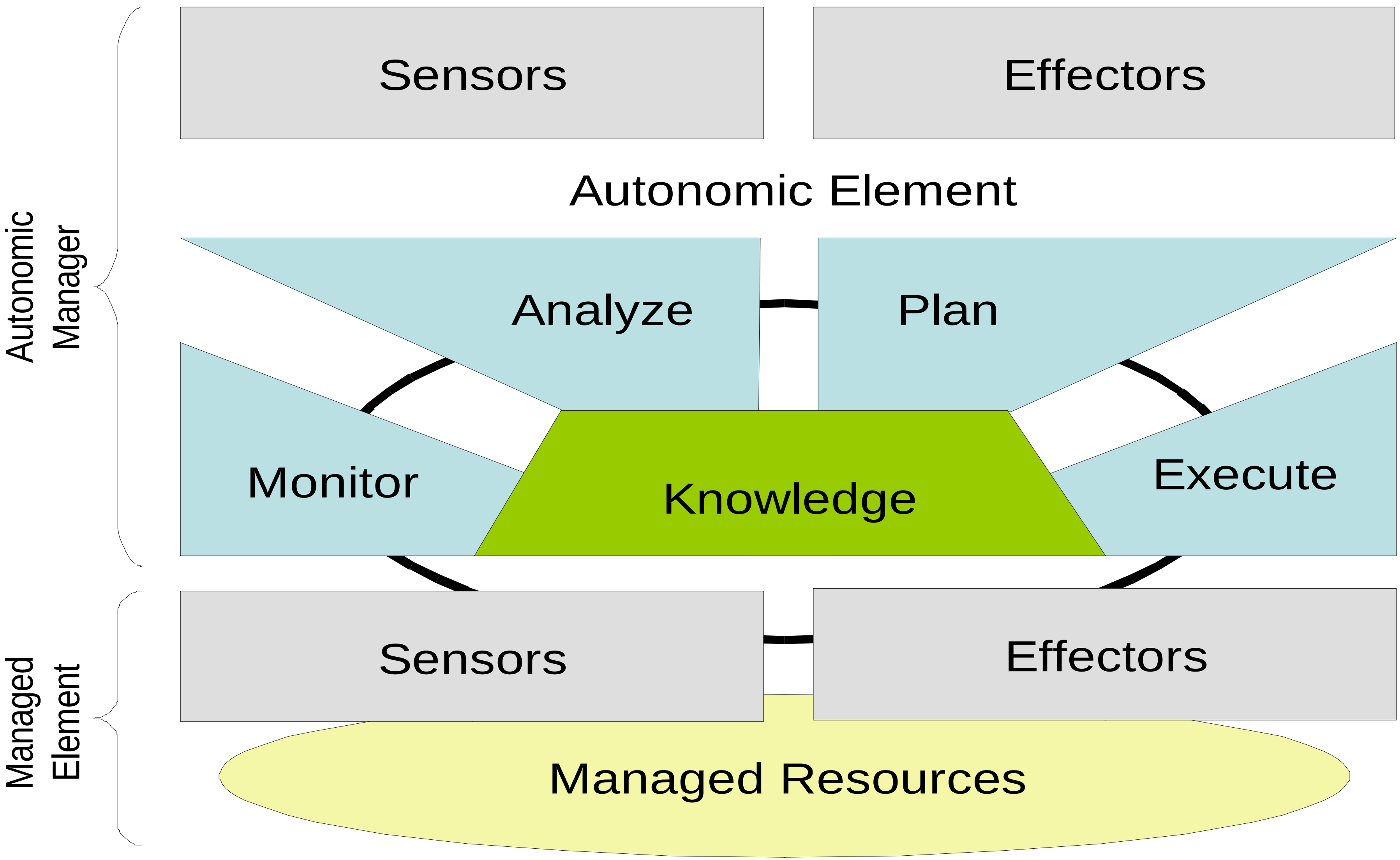
Ben Schultz



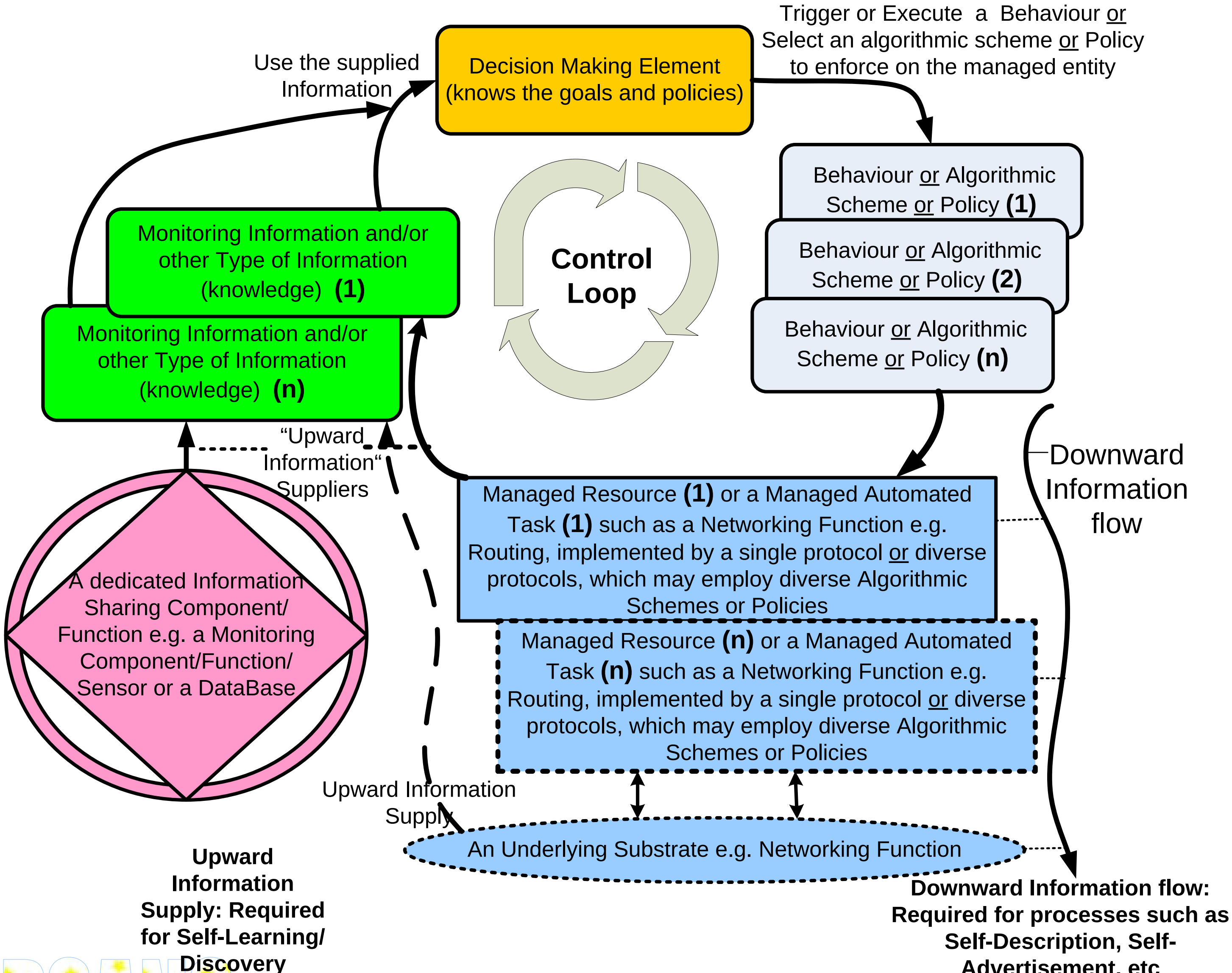
Cesar Viho

Hiroshi Miyata

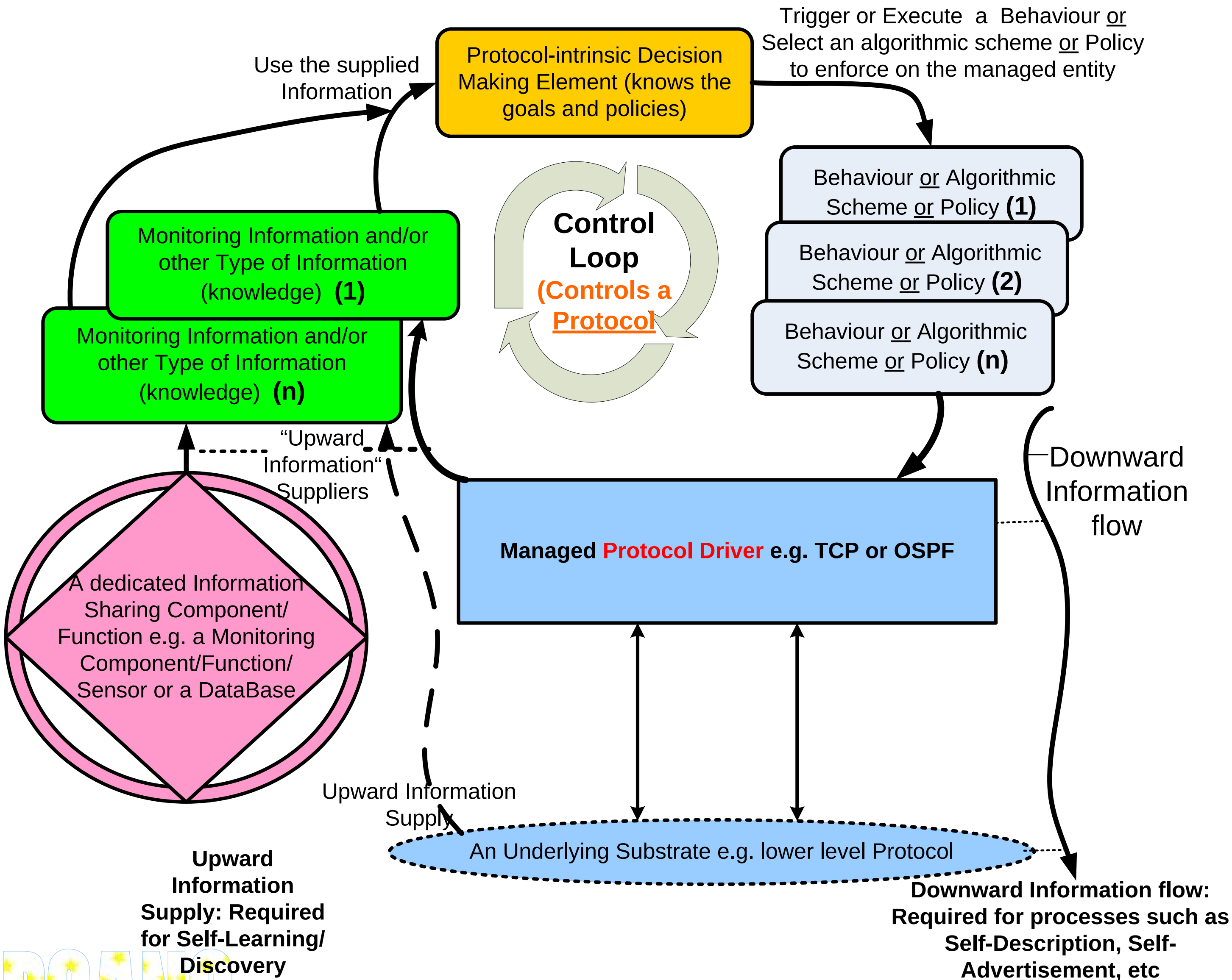
Autonomic Systems Engineering: Basic Concepts



Autonomic Systems Engineering: Concepts

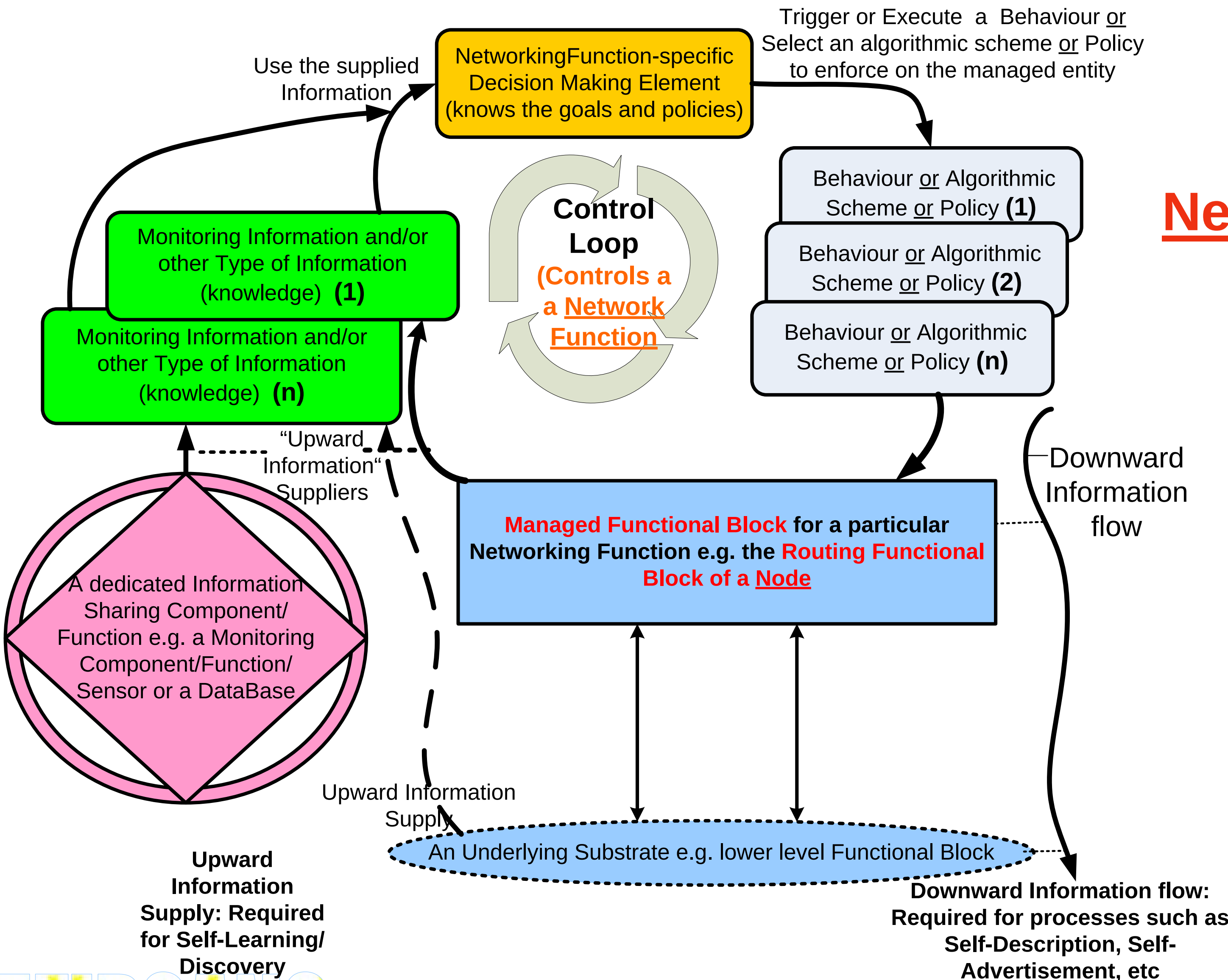


Protocol-intrinsic Decision Making Element



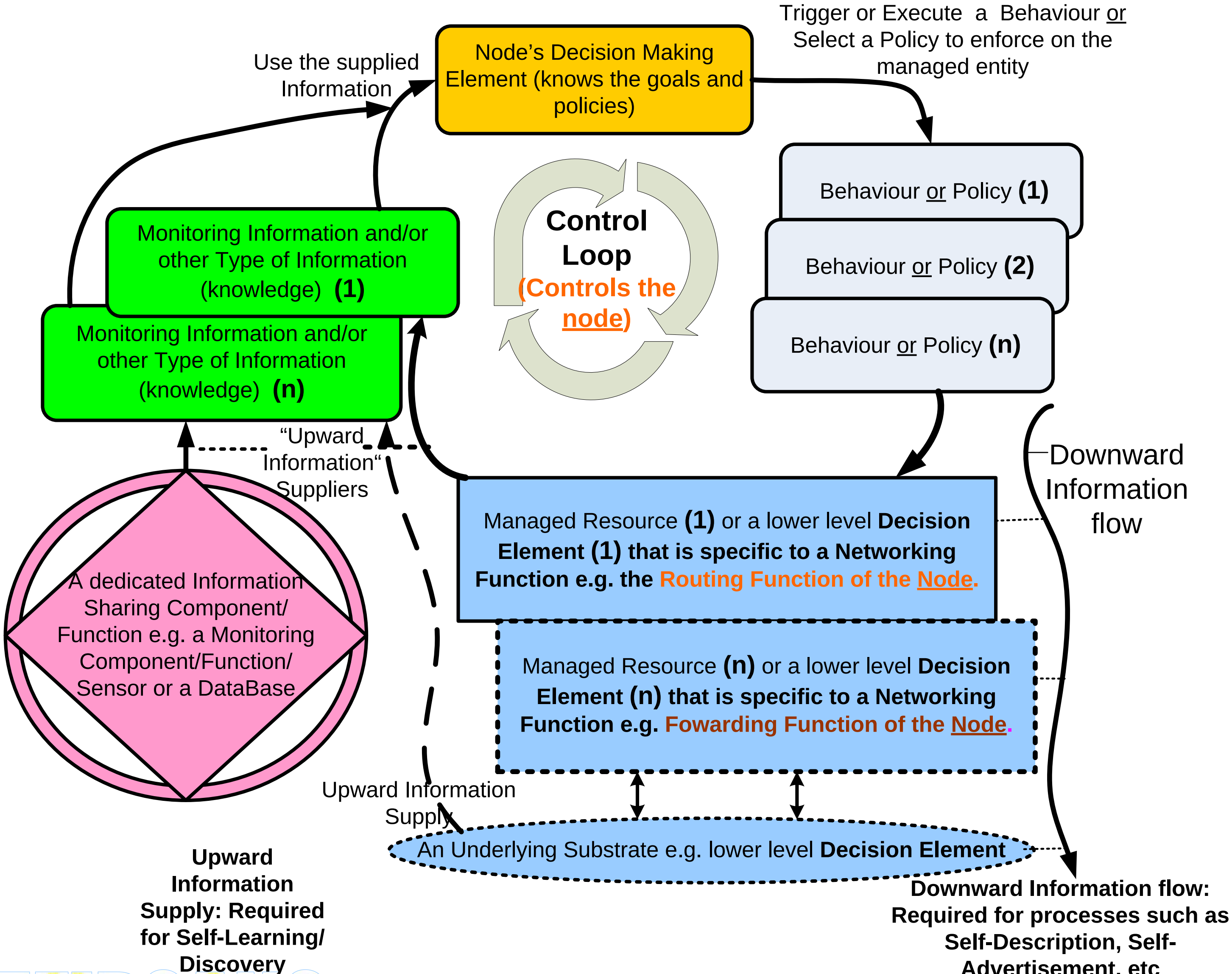
A protocol-intrinsic Control Loop

NetworkingFunction-specific Decision Making Element



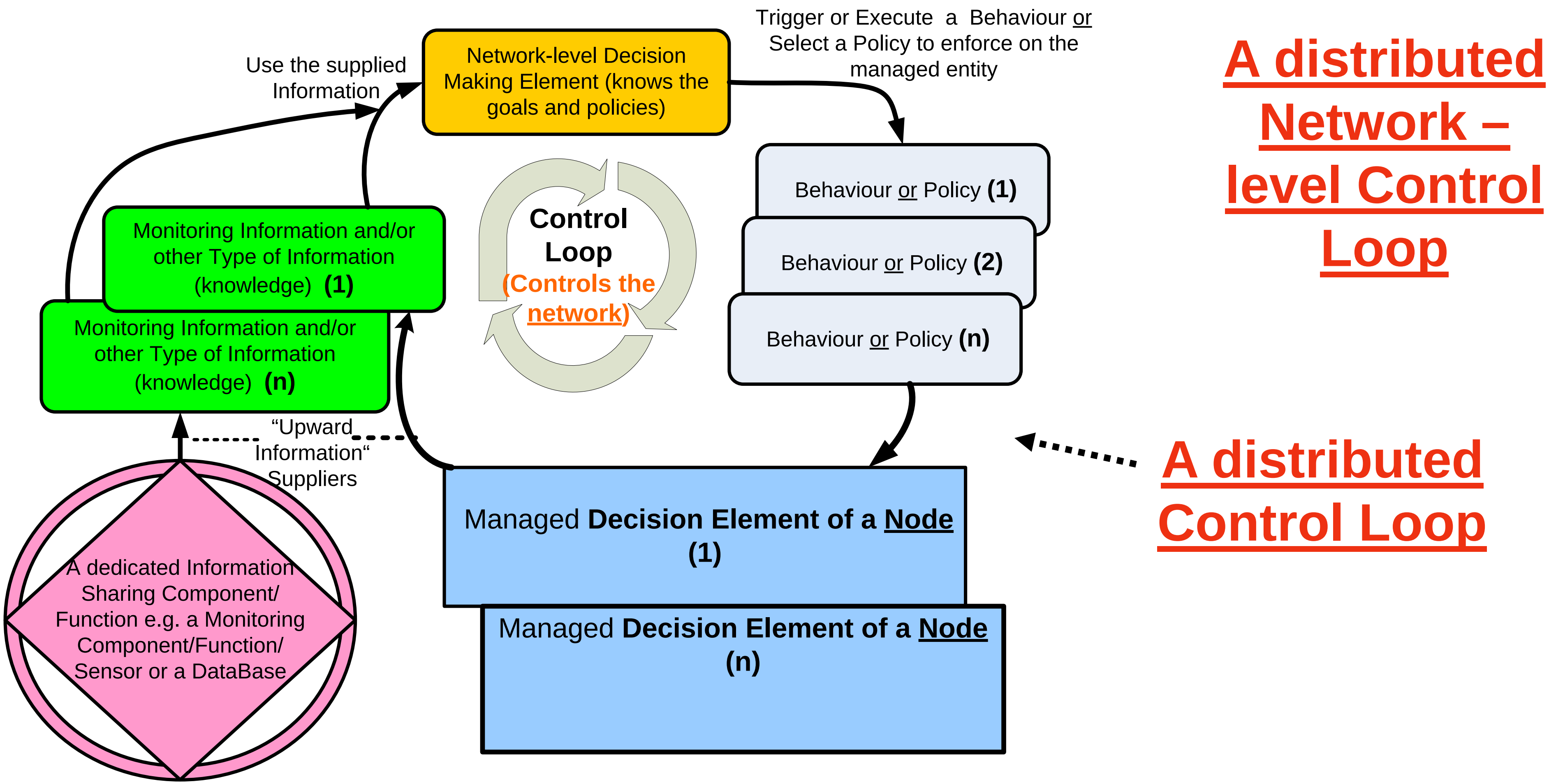
A NetworkingFunction-specific Control Loop

The Decision Making Element for the node



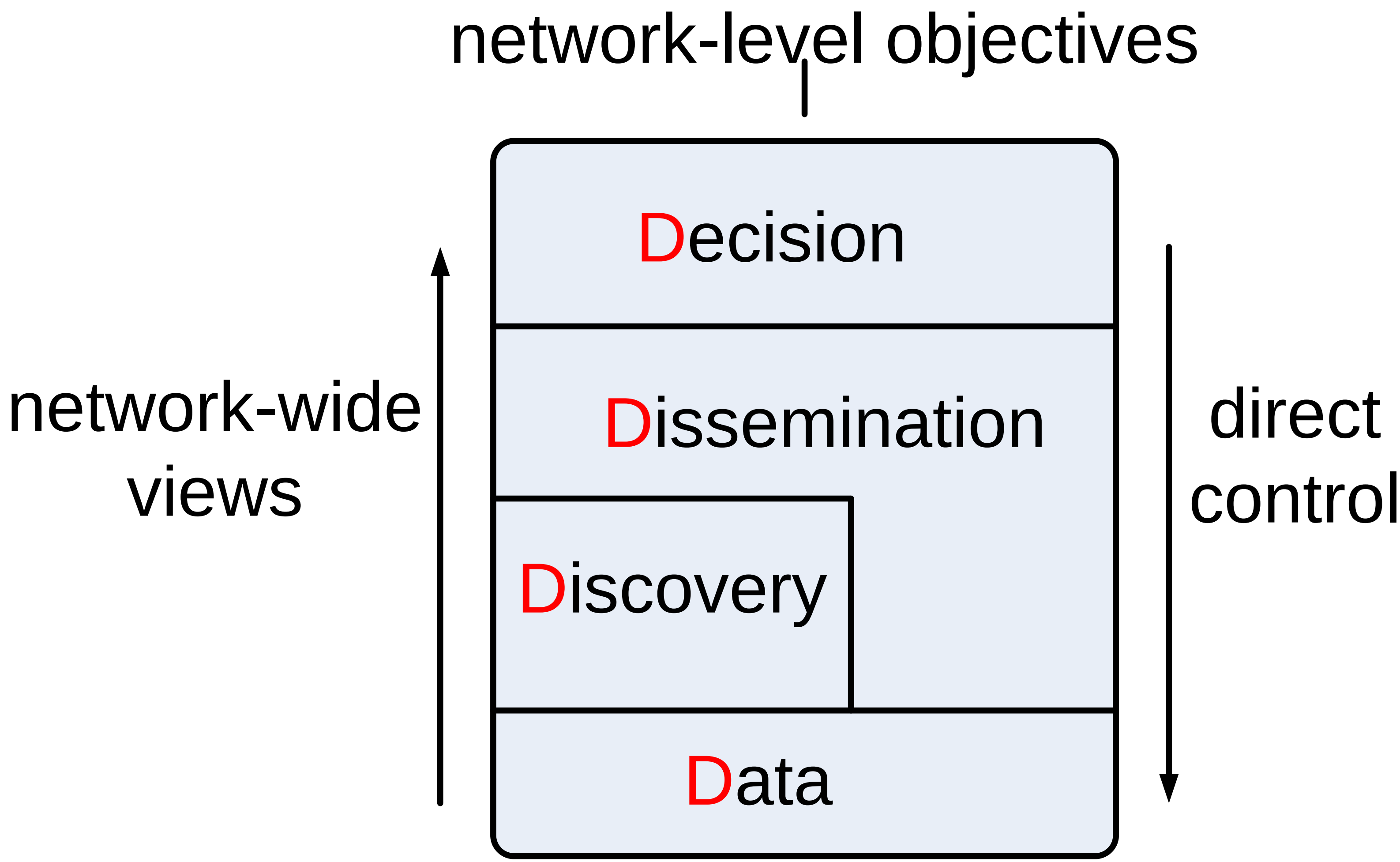
A Node's main control loop

Network-level Decision Making Element



The 4D Architecture

Refactoring Network Control and Management



Principles of the 4D Architecture

Network-level objectives: Running a robust data network depends on satisfying *objectives for performance, reliability, and policy* that can (and should) be expressed separately from the low-level network elements.

- For example, a traffic-engineering objective could be stated as "keep all links below 70% utilization, even under single-link failures." A reachability policy objective could be stated as "do not allow hosts in subnet B to access the accounting servers in subnet A."

Network-wide views: *Timely, accurate, network-wide views of topology, traffic, and events are crucial for running a robust network.* The network-wide view must accurately reflect the current state of the data plane, and include accurate information about each device, including its name, resource limitations, and physical attributes.

Direct control: *Satisfying network-level objectives is much easier with direct control over the configuration of the data plane*. The decision logic should not be hardwired in protocols distributed among nodes and switches. Rather, only the output of the decision logic should be communicated to nodes and switches.

Planes of the 4D Architecture

- **Decision plane:** ***<u>The decision plane makes all decisions driving network-wide control</u>*, including reachability, load balancing, access control, security, and interface configuration. Replacing today's management plane, the decision plane operates in *real time* on a network-wide view of the topology, the traffic, and the capabilities and resource limitations of the routers.**

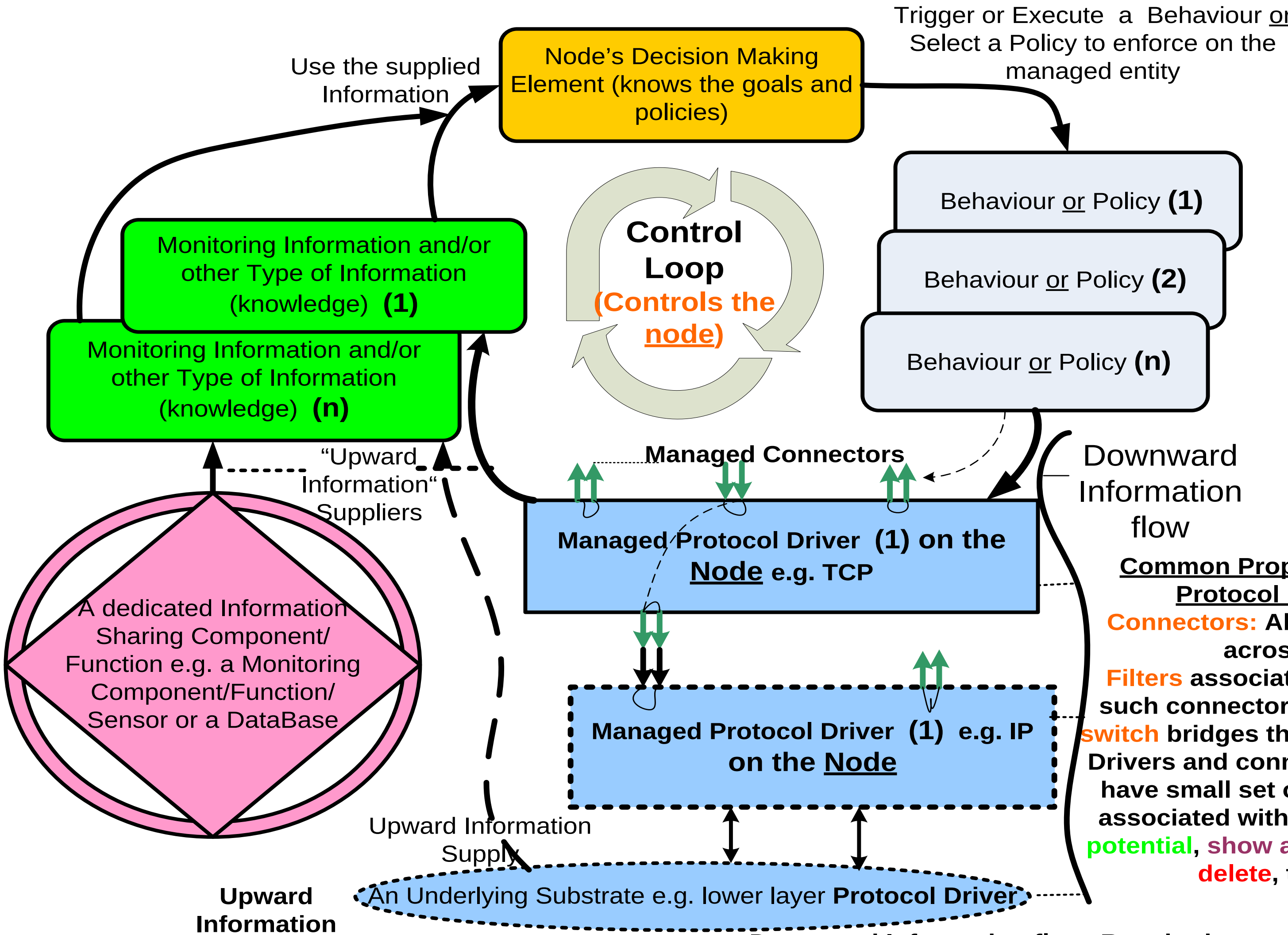
- **Dissemination plane:** ***<u>The dissemination plane provides a robust and efficient communication substrate</u>* that connects devices such as routers and switches with decision elements.**

Principles of the 4D Architecture

- **Discovery plane:** ***The discovery plane is responsible for discovering what physical entities make up the network and creating logical identities to represent those entities*****. The discovery plane defines the scope and persistence of the identities, and carries out the automatic discovery and management of the relationships between them. This includes box-level discovery (e.g., what interfaces are on this router? How many FIB entries can it hold?), neighbor-discovery, etc.**

- **Data plane:** ***The data plane handles individual packets based on the state that is output by the decision plane.*** **This state includes the forwarding tables, packet filters, link-scheduling weights, and queue management parameters, as well as tunnels and network address translation mappings.**

Deep 4D Architecture



Common Properties of a Protocol Driver

Connectors: Above, below, across. Filters associate with each such connector, An internal switch bridges the connectors. Drivers and connectors could have small set of Primitives associated with them: show potential, show actual, create, delete, test.

Upward Information Supply: Required for Self-Learning/ Discovery

Downward Information flow: Required for processes such as Self-Description, Self-Advertisement, etc

In a nutshell: Main Objectives, Success Criteria & Consortium

- EFIPSANS Objectives
- [*The Principal Objective*] - Aiming at exposing the features in IP version six protocols that can be exploited or extended for the purposes of Designing or Building Autonomic Networks and Services.
- Capture and Specify *desirable* autonomic(self-*) behaviours in diverse environments e.g. End Systems, Access Networks, Mobile, Wireless versus Fixed network environments. [Autonomic Behaviour Specifications (ABs) and Requirements Specifications (RQs) will be produced] [Nature of Control Loops & Interactions, etc]
- Appropriate IPv6 Protocol or Architectural Extensions that enable the Implementation of the captured desirable autonomic behaviours will be sought, designed and specified. [Recommendations Reports or Draft RFCs will be produced]
- A *selected set* of the specified Autonomic Behaviours in diverse environments will be Implemented and Demonstrated.
- Technical Reports on the concrete IPv6 feature combination scenarios including any new extensions used to implement the selected set of autonomic behaviours will be presented.
- Push for Standardization and Industrialization of the produced Autonomic Behaviour Specifications, the identified exploitable IPv6 features and "EFIPSANS-defined" new Protocol and Architectural Extensions.

EFIPSANS

Manufacturers

ERICSSON

Telcordia® Technologies

Alcatel·Lucent

FUJITSU

Research Organisations:

FOKUS

ΕΔΕΤ GRNET

Network Operator - Service Provider

Telefonica

velti

Universities

UNIVERSITÉ DU LUXEMBOURG

ΕΠΙΣΕΥ ICCS

TU berlin

BEIJING UNIVERSITY OF POSTS AND TELECOMMUNICATIONS 北京邮电大学

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EFIPSANS Objectives and Measurable Criteria

Objective 1: Requirements Capturing, Autonomic Behaviour Specifications (ABs) and Functional Requirements (fRQs) Specifications

- Specification of some targeted desirable Autonomic Behaviours (ABs) in selected diverse networking environments - Fixed line edge network equipment (e.g. ADSL, CPE's), MANETS, GPRS, IP based UMTS and 4G systems, WiFi, Mesh networks, Ad-hoc networks, Multi-Radio access technologies, WLAN, HDR [The scope will be narrowed].

- Examples of Autonomic Behaviour Specifications (ABs): - self-adaptive routing in the core network, collaborative self-diagnosing network-wide behaviour, dynamic self-configuration, self-association in end systems, self-healing across protocol stacks and the network as a whole, etc.

- Specify and make use of User Requirements (uRQs), like context-aware and situation-aware communications, etc.

Next: Designing a Set of 17 Frameworks

- Each of the 17 Frameworks sought will mean ALL OR some of the following aspects:
  - Designing of a new architecture(s) where required,
  - Designing of components of individual architectures specific to the target framework,
  - Designing of mechanisms, protocols, or paradigms employed by the components in achieving the defined communication goals,
  - Details on how the whole framework can be implemented,
  - Software Prototypes or Tools for individual components of the architectural framework,
  - A detailed Functional Description of network function feature combination scenarios based on existing architectures and network functions.

Required: EFIPSANS Frameworks

Objective 2: Identify exploitable existing features in IPv6 Protocols and compose concrete feature combination scenarios that are required to help implement individual Autonomic Behaviours (ABs) specified by WP1.

- **Deep examination of existing IETF IPv6 RFCs. The work towards achieving objective 2 also includes the goal of Requirements Specifications (RQs) in terms of functional requirements (fRQs) such as *the enabling concepts, protocols, protocol features, architectures, and algorithms that help implement the captured (specified) desirable autonomic behaviours in selected diverse networking environments.***

Example fRQs'

- ***Intelligent control information exchange among nodes, novel network management functions, advanced auto-configuration, auto-discovery, proactive resilience and security, context-aware communication, components and mechanisms for "knowledge/information" flow in the network, cross- layering, etc***

Required: EFIPSANS Frameworks

Objective 3: Provide frameworks for required new complementary extensions to IPv6 protocols that are required to help implement individual Autonomic Behaviours (ABs) specified by WP1.

- Objective 4: Provide frameworks for required new complementary Networking Components, Algorithms, and Paradigms that are required to help implement individual Autonomic Behaviours (ABs) specified by WP1.

- EFIPSANS envisions the following extensions to IPv6 protocols and/or network architectures:
  - Horizontal Extensions -: New extension headers AND/OR additional protocol fields
  - Vertical Extensions -: Enhanced inter-layer interactions among IPv6 protocols, and between IPv6 protocols and other protocols of the stack, cross-layering etc; Architectural extensions in terms of *Primitives* for use by Network-Function specific *DecisionElements* for the control loops for autonomicity.
  - Component-wise Extensions -: New components similar to DNS, DHCP like type of components, e.g. *knowledge-base(storage) components* required for knowledge sharing and enabling autonomic behaviours in end systems, the access network and core networks, etc;
  - New Algorithms OR add-on mechanisms e.g. knowledge dissemination mechanisms, etc.

Demos/Trials–Validations of Results

Objective 5: ***Select a set*** **of the specified Autonomic Behaviours (ABs) for selected diverse network environments, in order to *Implement and Demonstrate Scenarios*. (*see TESTBED description on next page*)**

- ***Integrated Software Suites*** **that consist of Software Components developed as Prototypes in WP2, WP3, WP4, and WP5.**

The seven targeted main categories of autonomic functionality:

1. ***Autonomic Routing and Forwarding,***
2. ***Auto-Discovery and Auto-Configuration,***
3. ***Mobility and Autonomicity,***
4. ***QoS and Autonomicity,***
5. ***Resilience and Survivability,***
6. ***Self-Monitoring,***
7. ***Autonomic Fault-Management, as well as any other software components and paradigms such as role-based management, etc, contributed by tasks in WP2, WP3 and WP4.***

TestBeds

- The key TESTBED-- The Ericsson TESTBED will be build in such a way that it supports diverse networking environments according to the diverse networking environments for which Autonomic Behaviours (ABs) Specifications were carried out in WP1. The integrated testbed (Ericsson TESTBED) will consist of integrated network environments in which EFIPSANS software components will be deployed for showcasing autonomic behaviour scenarios in the targeted diverse environments namely:
  - Core Network Environments,
  - Access Network Environments(Wireless and fixed);
  - End Systems (Wireless and fixed);
  - Mobile Network Environment,
  - Terminal Mobility Zone that encompasses support for mobile end-devices, allowing a EFIPSANS test user to seamlessly roam in a heterogeneous access environment.
- All these environments will be integrated in such a way that autonomic behaviour(s) scenarios spanning a number of diverse environments can also be showcased.
- Other Testbeds such as the ACLab in Fokus, Telefonica Testbed, Fujitsu-LabsTestbed, Telcordia-Poland Testbed, PlanetLab, UL TestLab, NetMode-Lab, BUPT testbed, National CCG; and Testbeds from other individual Partners, will all be connected to the Ericsson TESTBED via Tunnels

Objective 6: Industrialization and Standardization

- Push for Standardization of the EFIPSANS produced:
  - The Autonomic Behaviour Specifications (ABs),
  - The identified exploitable IPv6 features and
  - "EFIPSANS-defined" new Protocol and Architectural Extensions that help implement the specified Autonomic Behaviours (ABs).

Industrial Exploitations, and Endorsement

Industrialization

Ericsson, world leader with 40% market share worldwide of Mobile Networks, Alcatel-Lucent and the other industrial partners are best suited for showcase for this project. Ericsson will target and use its Business Units to validate, test and exploit the results and recommendations of the EFIPSANS project using 6REF/6WINIT/Euro6IX.

Telcordia & Fujitsu (as 3GPP EPS (formerly SAE) in SA2, 3GPP E-UTRAN (Formerly LTE) and 3GPP IMS SWG in SA2. contributed to WIMAX Forum Networking (NWG) for their Release 1) will exploit the results and recommendations of the EFIPSANS project

Telefonica & Velti will test & exploit the results and recommendations of the EFIPSANS project

Autonomic Communication Forum:
Dr. Willie Donnelly is Academic Chair of the ACF (TSSG). FOKUS is a Steering Member of ACF.
John Strassner, President ACF, endorsed

One Laptop Per Child:

Key Research Topics and associated EFIPSANS Frameworks

1. Autonomic Behaviours (ABs) and Requirements(RQs) in End Systems, Access/Edge Networks and the Core Networks.

2. Autonomic Behaviours (ABs) and Requirements (RQs) in specific environments: Mobile network environments, as well as Wireless versus Fixed network environments.
3. Adoptions of new ideas from emerging Protocol Engineering paradigms.
   - Framework: F2: A draft of a generic multi-path cross-layer routing protocol.

4. Routing and Autonomicity in IPv6 Networks
   - Framework: F2.b: Novel routing mechanisms that can automatically adapt routing configuration, policy and algorithms to changes in the network topology.
5. Auto-configuration and dynamic/adaptive Self-Configuration
   - Framework: F4: Advanced Auto-configuration and dynamic (adaptive) self-configuration mechanisms in IPv6 nodes
6. Autonomic Control Information Exchange using ICMPv6 and EFIPSANS-defined extensions to relevant protocols of the ICMPv6 family of protocols - Framework: F1: A Framework for Autonomic Control Information Exchange …….

Key Research Topics and associated EFIPSANS Frameworks

7. **Introducing advanced techniques to the IPv6 Forwarding functionality defined by RFC2460**
   - Framework: F3: Novel IPv6 Forwarding techniques as ingredients for engineering autonomic behaviours.

8. **Mobility and Autonomicity in IPv6 Networks**
   - Frameworks: F6: Advanced seamless mobility mechanisms that efficiently support multihoming over an IPv6 heterogeneous wireless environment;
   - F7: Novel mechanisms that enable regional collaboration of various autonomic wireless networks under a common utility based integrated framework

9. **QoS and Autonomicity in IPv6**
   - Frameworks: F8: Mechanisms that will provide QoS guarantees for users' applications in autonomic IPv6 networks;
   - F9: Novel QoS architecture based on the identification of the interaction between autonomicity and the current QoS mechanisms

10. **Resilience, Survivability and/for Autonomicity in IPv6 Networks**
    - Framework: F10: Mechanisms, concepts, components and protocols that will improve the Resilience and Survivability in autonomic IPv6 networks

Key Research Topics and associated EFIPSANS Frameworks

11. Access, identification and security issues in autonomic IPv6 Networks

- Framework: F11: Roaming access polices, Trust Models (Security) and global identification provisioning in autonomic IPv6 enabled networks

12. Cross-Layer Usage

- Framework: F12: Autonomic mechanisms (functions) that will take advantage of cross layered information exchange.

13. Intrinsic Monitoring

- Framework: F5: Intrinsic Monitoring which is enabled by *EFIPSANS defined IPv6 Extension Headers* for conveying, collecting or aggregating monitoring information across nodes in an autonomic network as well as other complementary Information Sharing and Dissemination Mechanisms

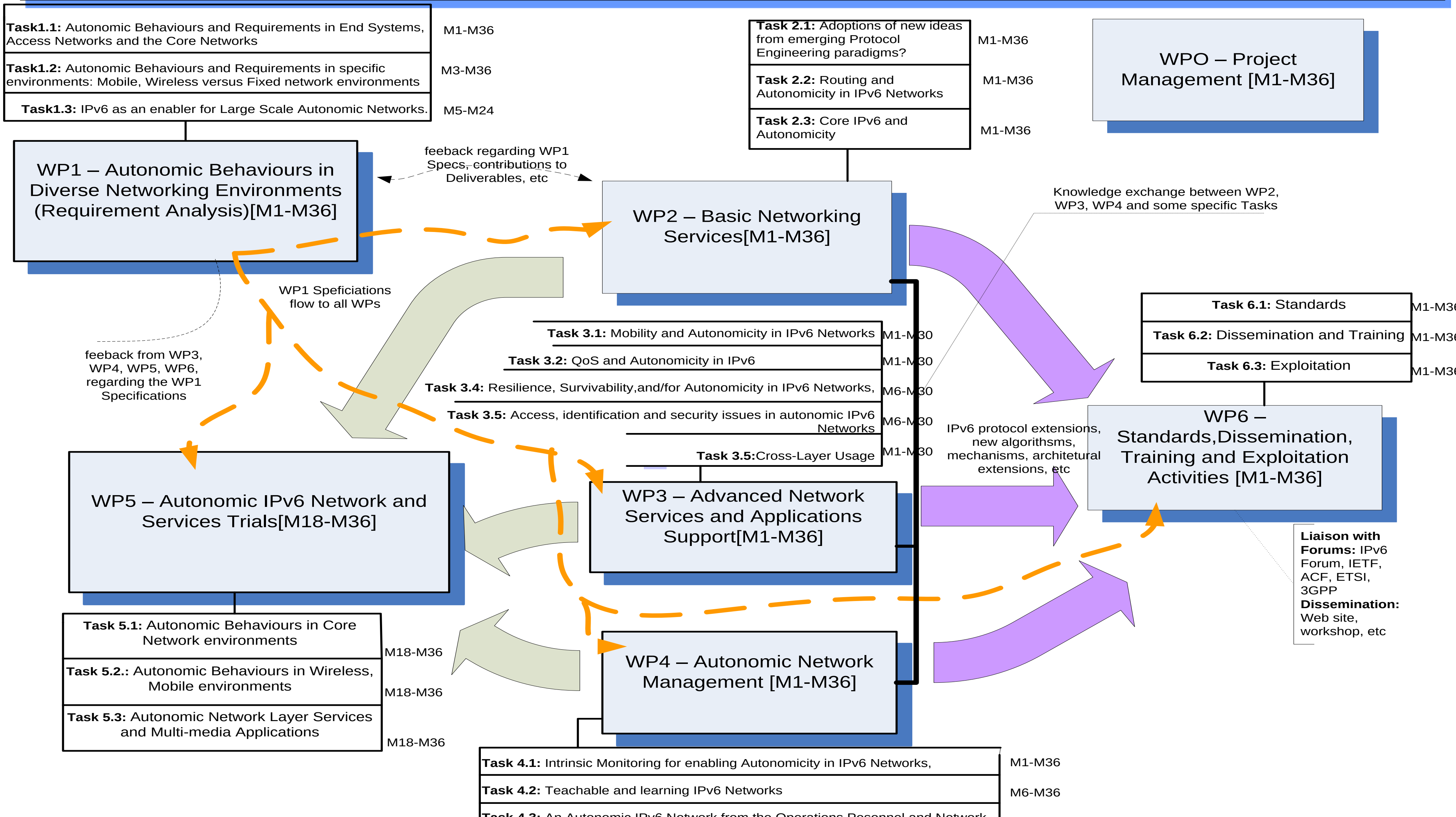
14. Teachable and Learning IPv6 Networks

- Framework: F13: Roadmap to implementing IPv6 nodes with “learning capabilities” that enable the network to learn how to self-manage.

Key Research Topics and associated EFIPSANS Frameworks

15. An Autonomic IPv6 Network from the Operations Personnel and Network Management points of view
    - Framework: F14: Tools for efficient network monitoring from the perspective of network operations personnel
16. The Implications of Autonomicity on the performance of applications and services
    - Frameworks: F15: Communication mechanism between an application and a autonomic node to provide role-based management;
    - F17: Performance monitoring information metrics, for use in dynamic autonomic behaviour
17. Components and Mechanisms for Autonomic Fault-Management
    - Framework: F16: Principles and components of Autonomic Fault Management.

WPs Structure



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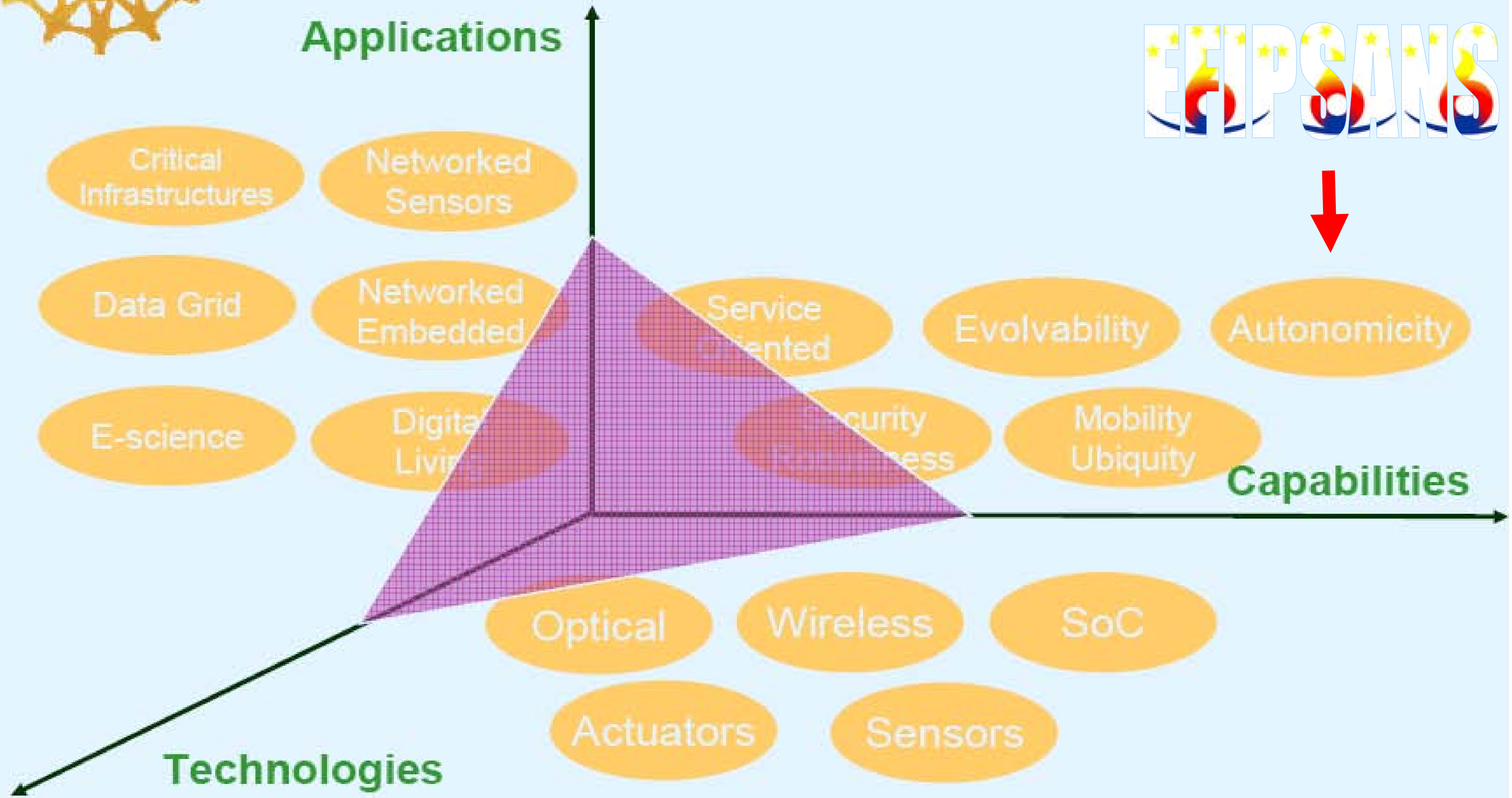
GENI: Global Environment for Networking Innovations

Peter A. Freeman, Ph.D.
Assistant Director US National Science Foundation
for Computer and Information Science and Engineering



Thank You ……..!