A Unified Management Framework for autonomic and software-defined networks

IETF 86 – 29th NMRG meeting

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OVERVIEW

MOTIVATIONS

UMF IN A NUTSHELL

UMF AND SDN

STANDARDIZATION OPPORTUNITIES

MOTIVATIONS

MOTIVATIONS
PROBLEM STATEMENT

Simple facts/observations on today's networks:

- Increasing volume of traffic
- Increasing number of devices/interactions (e.g. Machine-to-Machine)
- Increasing number of services and related QoS constraints
- (still) technology heterogeneity and legacy
- (still) technology/administrative silos

Which generates the following problematic situation and detrimental impacts:

- Complexity of distributed systems and their control/management
- Reaching the limit of current management/operation practices
  - scalability, speed, highly human–dependent
- Network capabilities under-utilization
  - worst-case/over provisioning, unused advanced features
- New service or application deployment difficulty
  - slow time-to-deploy and tedious multi-techno/vendor mapping

MOTIVATIONS
GOAL

The ultimate goal of self-managing networks is to overcome these limits by providing intelligent, adaptive, modular, and automated carrier-grade control functions for seamless, end-to-end and cross-technology interworking

Objectives

- Multi-facet unification
  - Federation of existing architectures and unification management principles across multiple technologies
- Network empowerment
  - Embed intelligence to achieve true self-managing networks
- Industry readiness
  - Demonstrate deployability and develop migration strategies for adoption by telcos/vendors
- Trust and confidence
  - Demonstrate the reliability of every autonomic solution and develop standard testing and certification

In this context, standardization is a must!

MOTIVATIONS
CHALLENGES

- Genuine research challenges (still) exist to design and develop algorithms and mechanisms capable of replacing human operation | expertise | reasoning.

- An important and complex research challenge arises for the coordination of interactions among autonomic entities (conflict-resolution, stability assurance, multi-objective optimization)

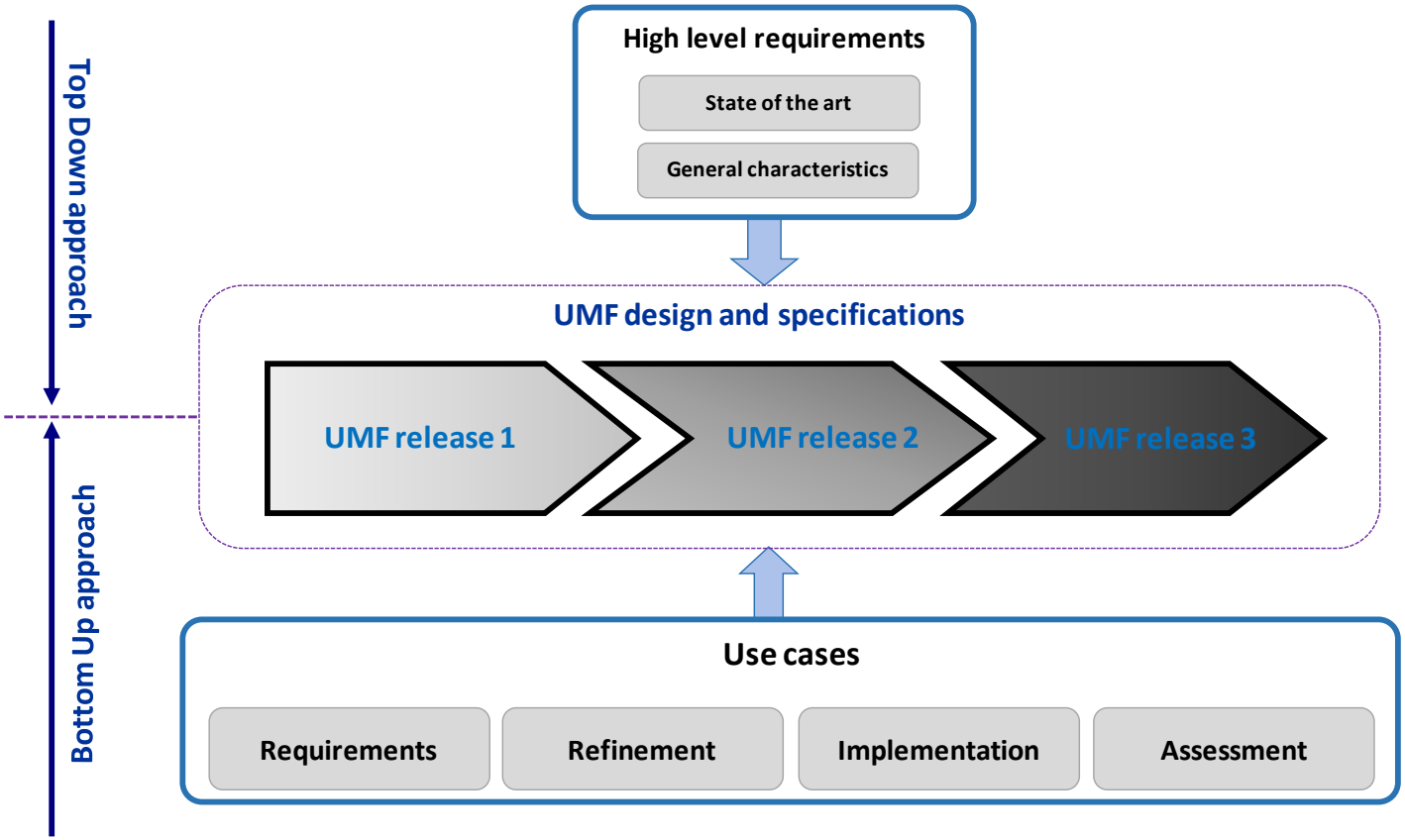
- New solutions have to be extensively and rigorously tested and exercised on real use cases and field trials to prove their applicability in carrier-grade environments and build trust and confidence from the operators in their performance and safe behaviors.

- A unified framework is then needed to enable seamless, plug-and-play deployment and interoperable operations of the autonomic mechanisms. Designing this unified framework is a challenge in itself besides the required efforts for (pre-)standardization.

Most importantly, these four research challenges should be addressed concurrently which increases the difficulty of the task.

UMF IN A NUTSHELL

UMF IN A NUTSHELL
TOWARDS A REFERENCE FRAMEWORK



Solid, well-recognized understanding and knowledge of a specific domain, aiming at improving reuse of design expertise and productivity, facilitating the development of systems of that domain[1]

[1] Nakagawa et al., Using systematic review to elicit requirements of reference architectures, in WER 2011.

UMF IN A NUTSHELL
NETWORK EMPOWERMENT MECHANISM

Approach: The right key to the lock

- Use the relevant method to solve a concrete operational problem in a specific networking environment
- Realize a purposeful self-management function (closed control loop)

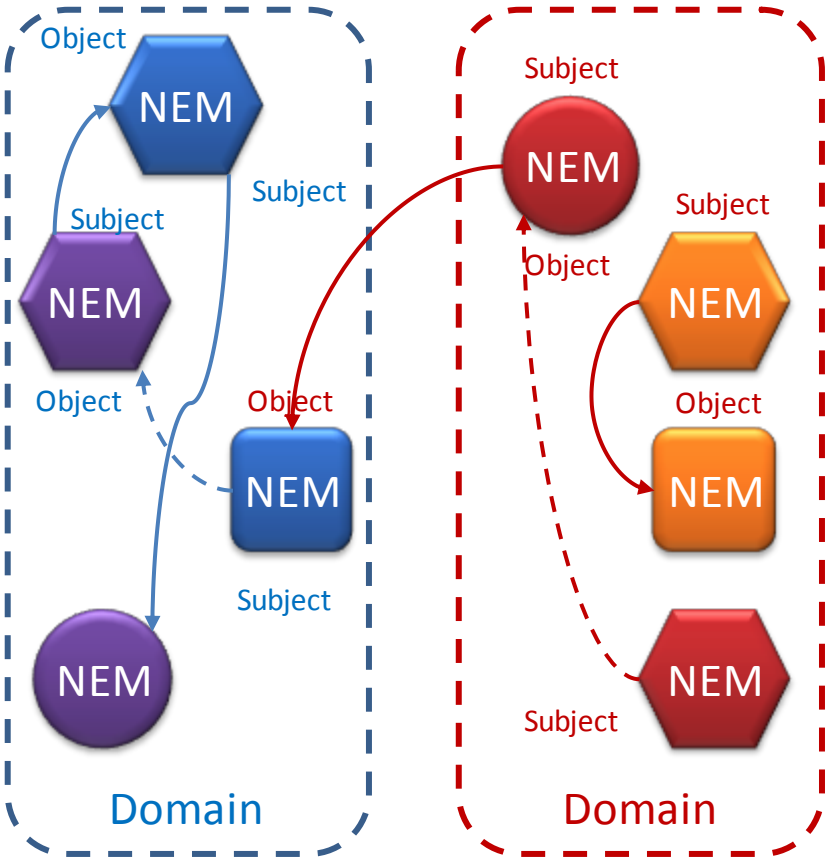
NEM = method + objective + context

- Use of Bayesian inference for fault diagnosis in FTTH networks
- Use of Genetic algorithm for interference coordination in LTE networks
- Use of Self-organizing maps for Congestion Prediction in Core IP networks

NEM = abstraction of an autonomic function

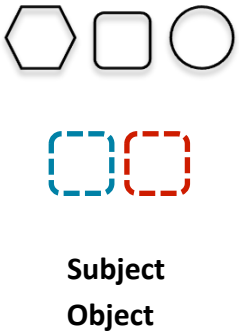
- External interfaces (called “skin” in the UMF terminology)
- Description, properties, capabilities, behavior (called “manifest” in the UMF terminology)
- Enabling to capture also interactions and relationships with other NEMs
- Providing uniform model and control means

UMF IN A NUTSHELL
COPING WITH DIVERSITY



Ecosystem diversity

- Multiple heterogeneous NEMs
- Multiple technology domains
- Multiple roles per NEM
- NEMs interact
  - Intra-domain
    - ✓ Explicitly | Implicitly
  - Inter-domain
    - ✓ Explicitly | Implicitly



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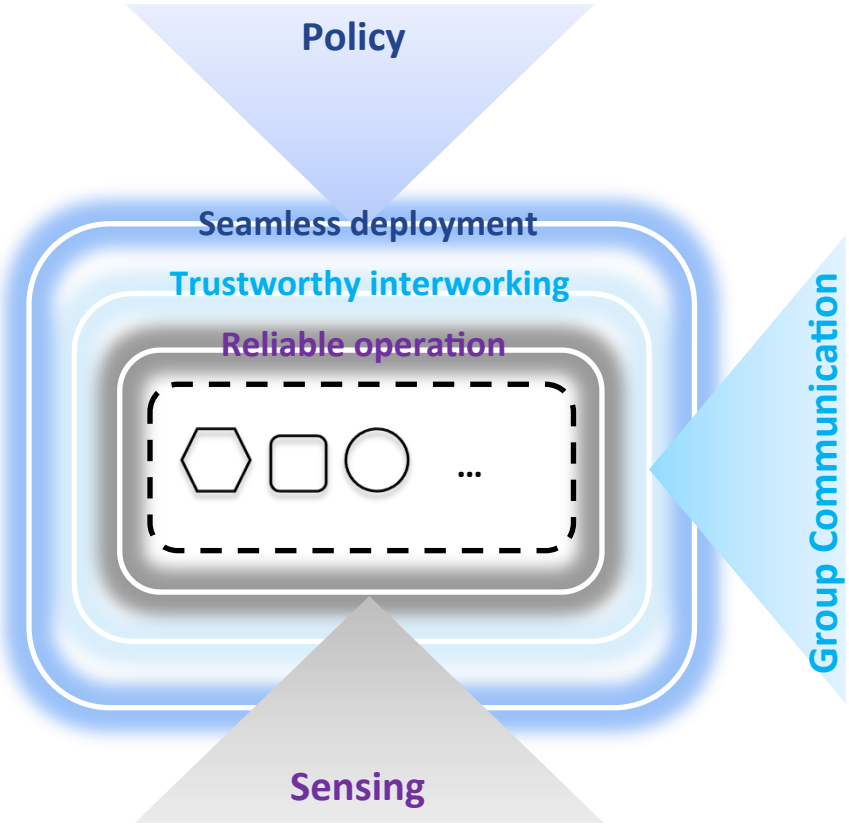
UNIFICATION



Commonalities

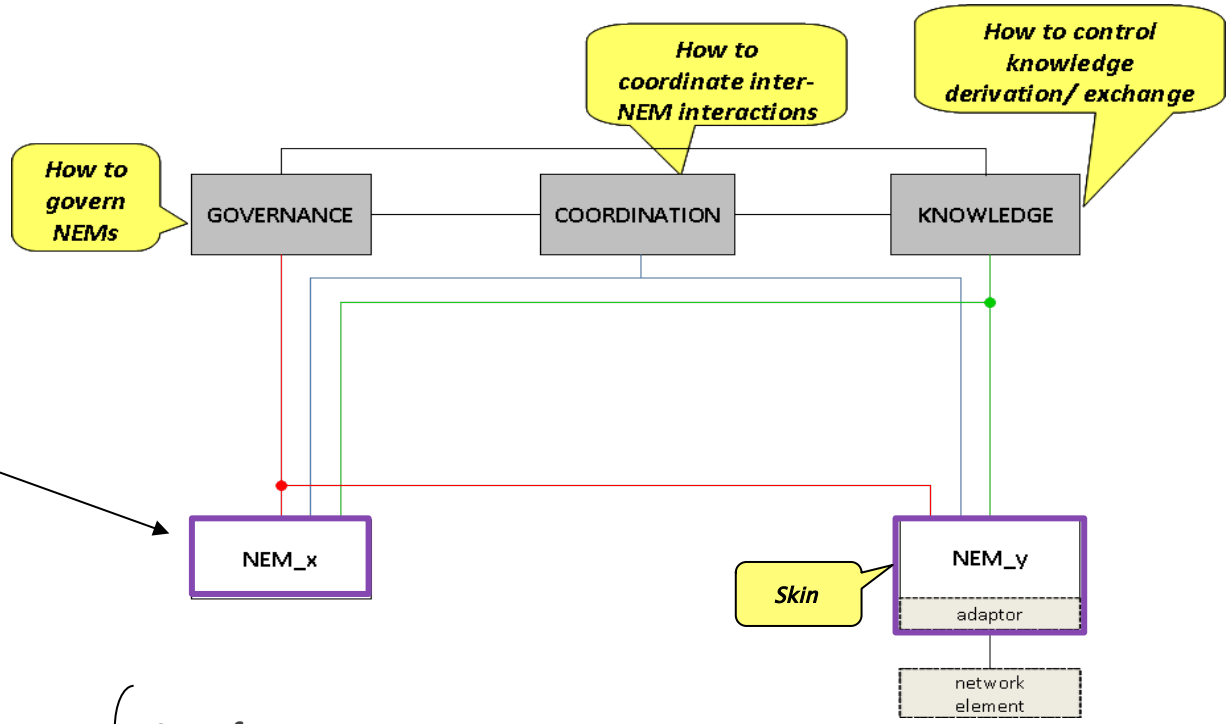
- Common borders for a domain
- Same hierarchy
  - Reliable operation
  - Trustworthy interworking
  - Seamless deployment
- Same interfaces
  - Policy
  - Group communication
  - Sensing

UMF IN A NUTSHELL
UMF CORE FUNCTIONAL BLOCKS

Seamless deployment and trustworthy interworking of NEM army require:

- Tools for the operators to deploy, pilot, control and track progress of NEMs in a unified way
  - **GOVERNANCE functional block**
- Tools to identify/avoid conflicts and ensure stability and performance when several NEMs are concurrently working
  - **COORDINATION functional block**
- Tools to make NEMs find, formulate and share relevant information to enable or improve their operation
  - **KNOWLEDGE functional block**
- APIs to enable NEMs “plug and play” deployment, interoperability and monitoring/configuration
  - **NEM Skin**
  - **Specific adaptors**

UMF IN A NUTSHELL
UMF CORE FUNCTIONAL BLOCKS



Objective of the UMF Core:

Seamless and trustworthy deployment of NEMs

Accomplished by specification, and then standardization, of:

- **Interfaces**
- **Coordination schemes**
- **Communication patterns**
- **Knowledge structures**
- **Policy translation levels**
- **Ontology**
- **Recommendations for NEM development** (lifecycle, generic structure…)

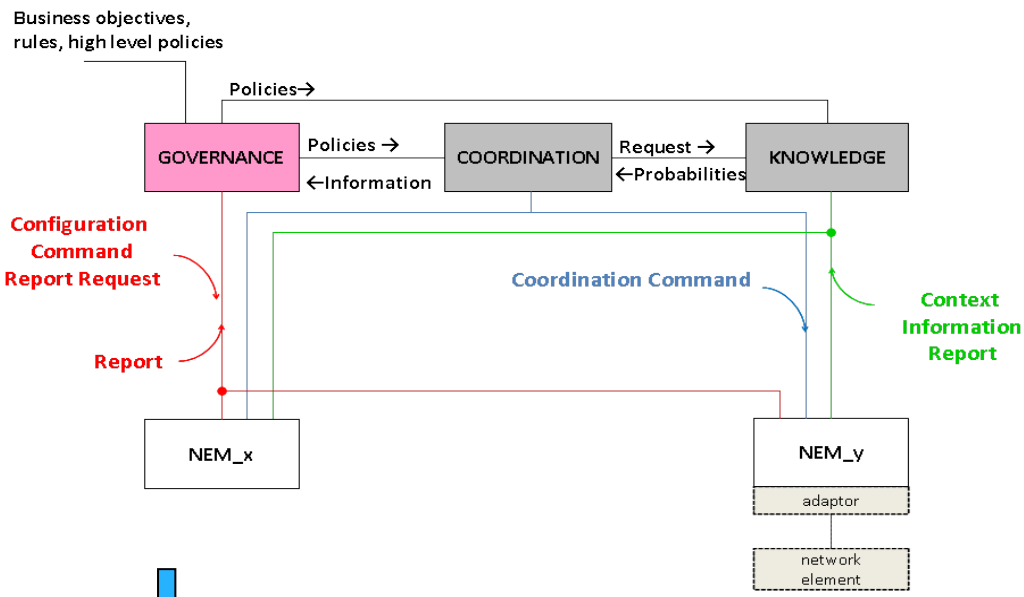
UMF IN A NUTSHELL
UMF CORE FUNCTIONAL BLOCKS

Responsible for:

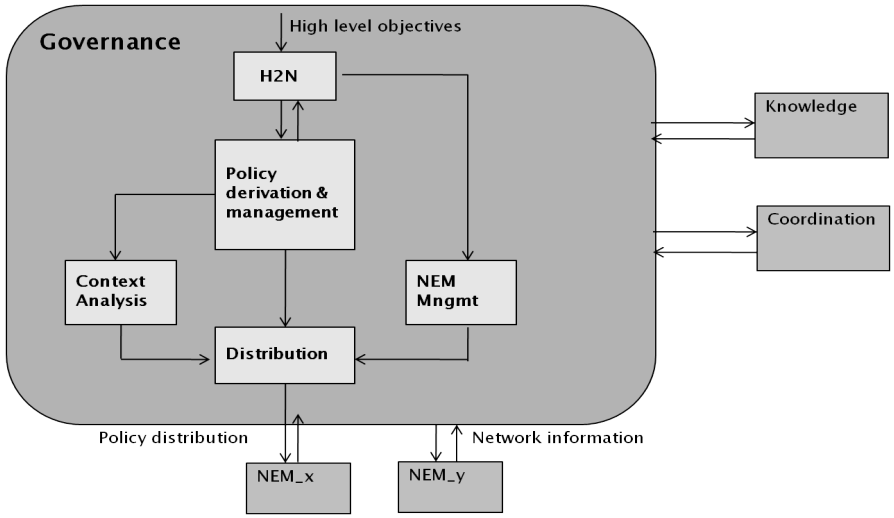
- The interaction between human operator and its network→ express business goals report on critical states of self-managed operations/ devices
- Driving NEMs' behavior→ policy-based framework for translating business-level, service specific goals/requests into low level, policies and configuration commands

GOVERNANCE ←→ NEM:

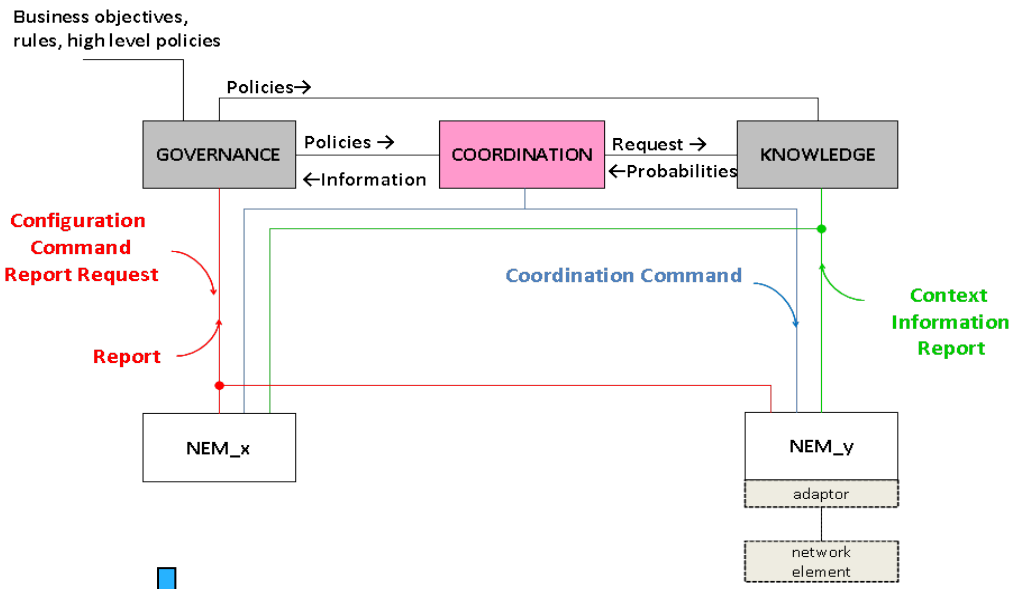
- Commands to set NEM's status/mode (e.g. active, idle, stopped) and configure its operational parameters.
- Report on the NEM's operational conditions and configuration characteristics (e,g. performance indicators, capabilities/ behaviour, interaction with other NEMs).



Functional decomposition



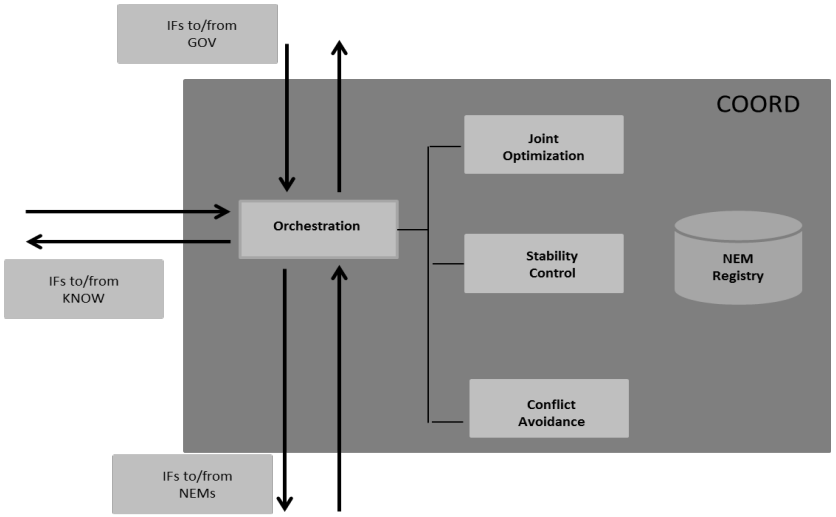
UMF IN A NUTSHELL
UMF CORE FUNCTIONAL BLOCKS



Responsible for:

- Ensuring the proper sequence in triggering of NEMs and the conditions under which they will be invoked taking into account:
  - ✓ Operator and service requirements,
  - ✓ Needs for Conflict avoidance, joint optimization and stability control.

Functional decomposition



COORDINATION ←→ NEM:

- Commands to drive coordination including: tokens, timing, constraints, status (active/ idle), etc.
- Information on the NEMs operation including: parameters, metrics, scope, utility functions, etc.

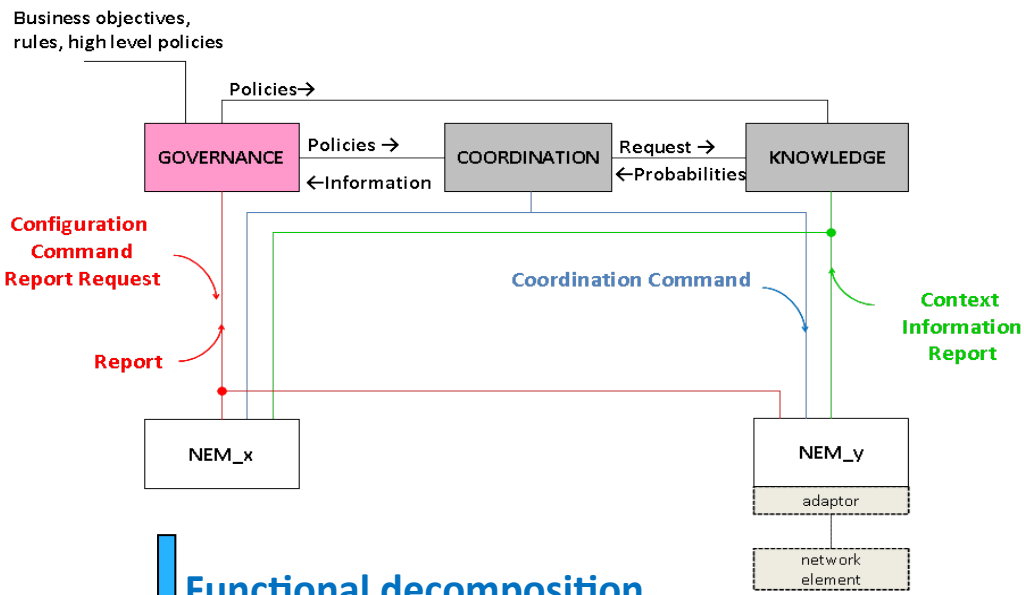
UMF IN A NUTSHELL
UMF CORE FUNCTIONAL BLOCKS

Responsible for:

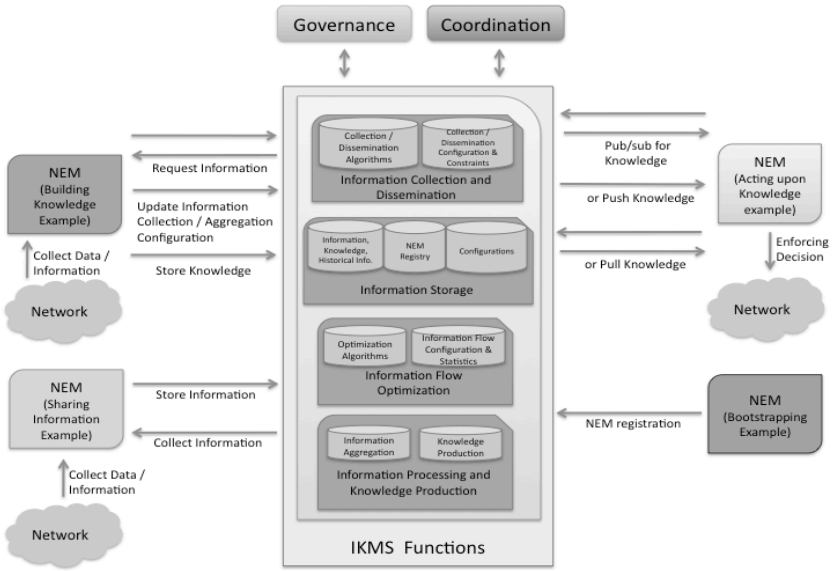
- Providing the suitable probabilistic models methods and mechanisms for derivation and exchange of Knowledge, based on :
  - ✓ Context and configuration information from NEMs,
  - ✓ Policies from Governance,
  - ✓ Information on NEM interactions from coordination

KNOWLEDGE ←→ NEM:

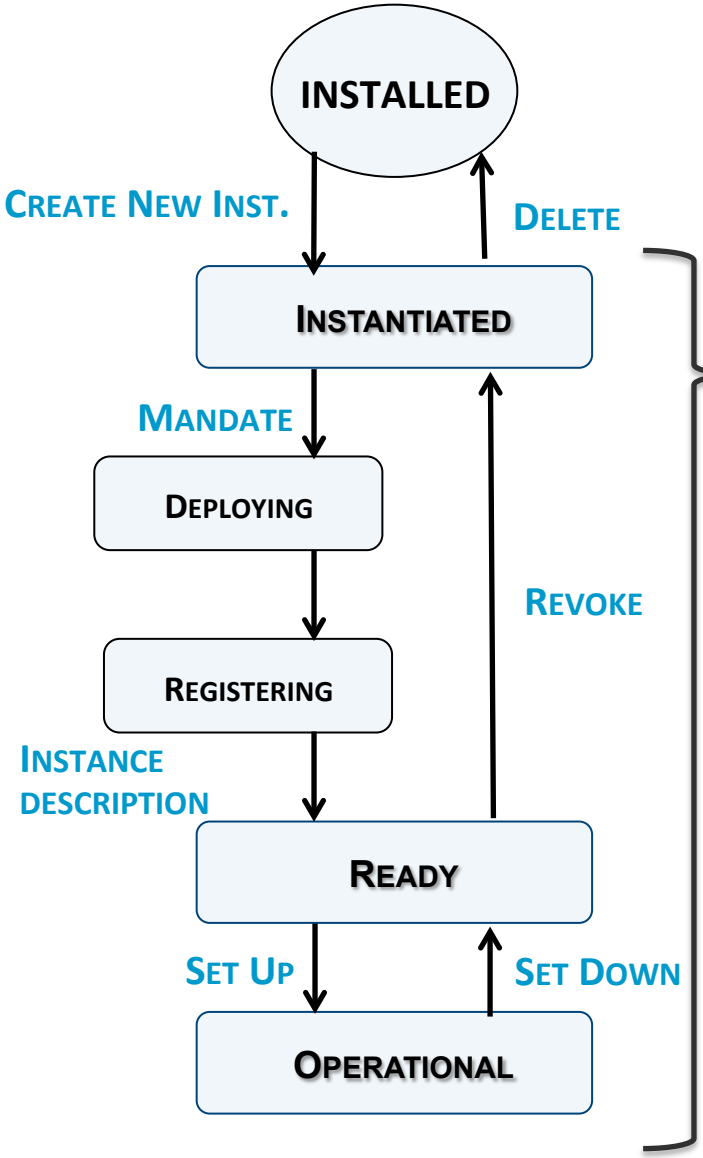
- Commands to retrieve, share, derive and manage knowledge including: publish, subscribe, push, pull, request, store, notify … messages.
- Registration of NEMs.



Functional decomposition



UMF IN A NUTSHELL
NEM LIFECYCLE



NEM Class (software)
described by MANIFEST (machine readable)

NEM Instance
described by INSTANCE DESCRIPTION

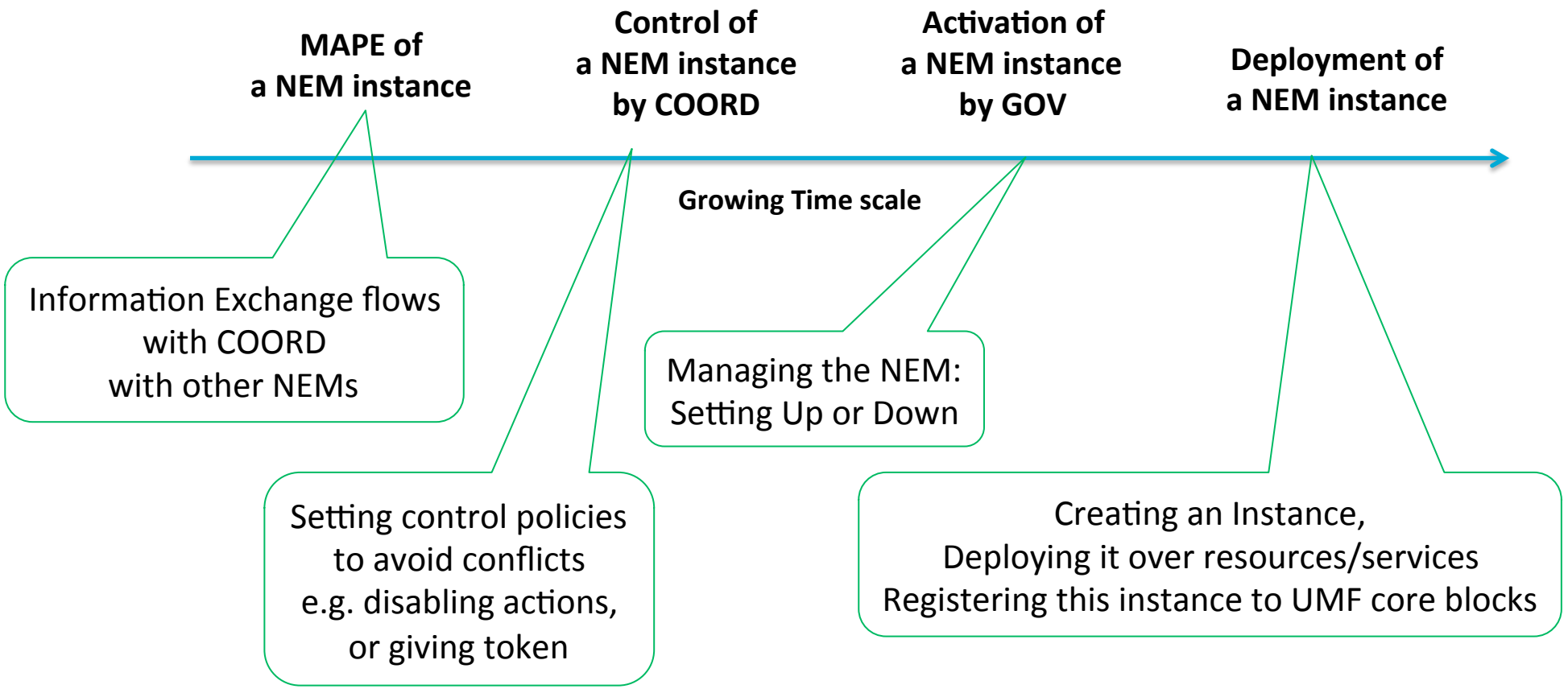
Life-cycle:

Detail the states and transition of a NEM instance, from its being installed, to it running its MAPE autonomic loop.

Steps include all the management by the UMF core functional blocks.

UMF IN A NUTSHELL
TIME SCALE

Different time scales, different events



UMF IN A NUTSHELL
INFORMATION MODEL

UMF information model TMF SID-compliant

- Provide formal UMF specification based on a standardized subsets of TMF SID
- Ensure coherence between implemented classes generated from IM classes
- Used to model the exchanged data and the policy structure within the governance block
- Ease UMF integration in telcos IS environment

Design approach

- UMF concepts defined and mapped to SID
- New concepts added via SID patterns e.g. NEM information model

UMF IN A NUTSHELL
SUMMARY

A unified framework to deploy and control self-managing functions

- Specifications of the UMF core functional blocks
- Specifications of the NEM
- UMF and NEM APIs (skin) and workflows/sequence charts
- Publicly available specifications, developer guidelines
- Implemented, tested, modular and re-usable components
  - NEM skin
  - RESTful APIs

UMF AND SDN

UMF and SDN

UMF defines the necessary abstractions/APIs

- for autonomic functions (NEMs)
- from the management point of view (UMF functional blocks)

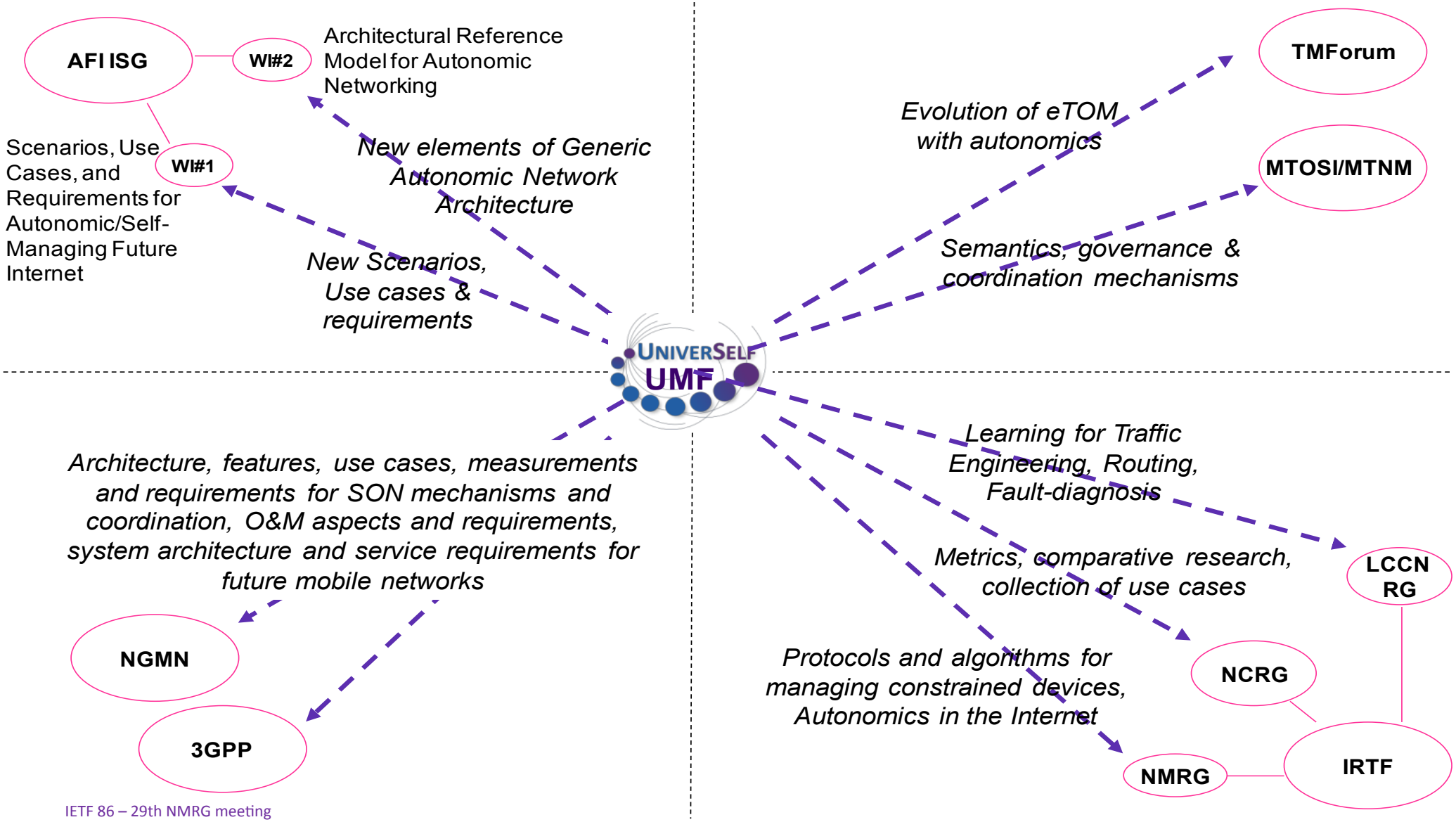
SDN is essentially about abstractions and APIs

Complementarity where the abstractions will meet

- Starting by identifying SDN management requirements and specificities

STANDARDIZATION OPPORTUNITIES

STANDARDIZATION OPPORTUNITIES



QUESTIONS & ANSWERS

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The research leading to these results has been performed within the UniverSelf project (www.univerself-project.eu) and received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 257513

PROJECT ID

- FP7 Call 5 Integrating Project
- Total Cost: ~16M€ ; EC Contribution: ~10M€

- 16 Partners (3 Vendors, 4 Operators, 4 Research Institutes, 5 Universities)
- Coordinator: Alcatel-Lucent
- Duration: 36 months
- Start date: 01/09/2010
- Website: www.univerself-project.eu

CONSORTIUM

BACKUP SLIDES

UMF IN A NUTSHELL
CAPABILITY LEVELS

0 – Reliable operation of a standalone NEM

- 0.1: Reliable decision making under noise
- 0.2: … with context awareness
- 0.3: … with prediction

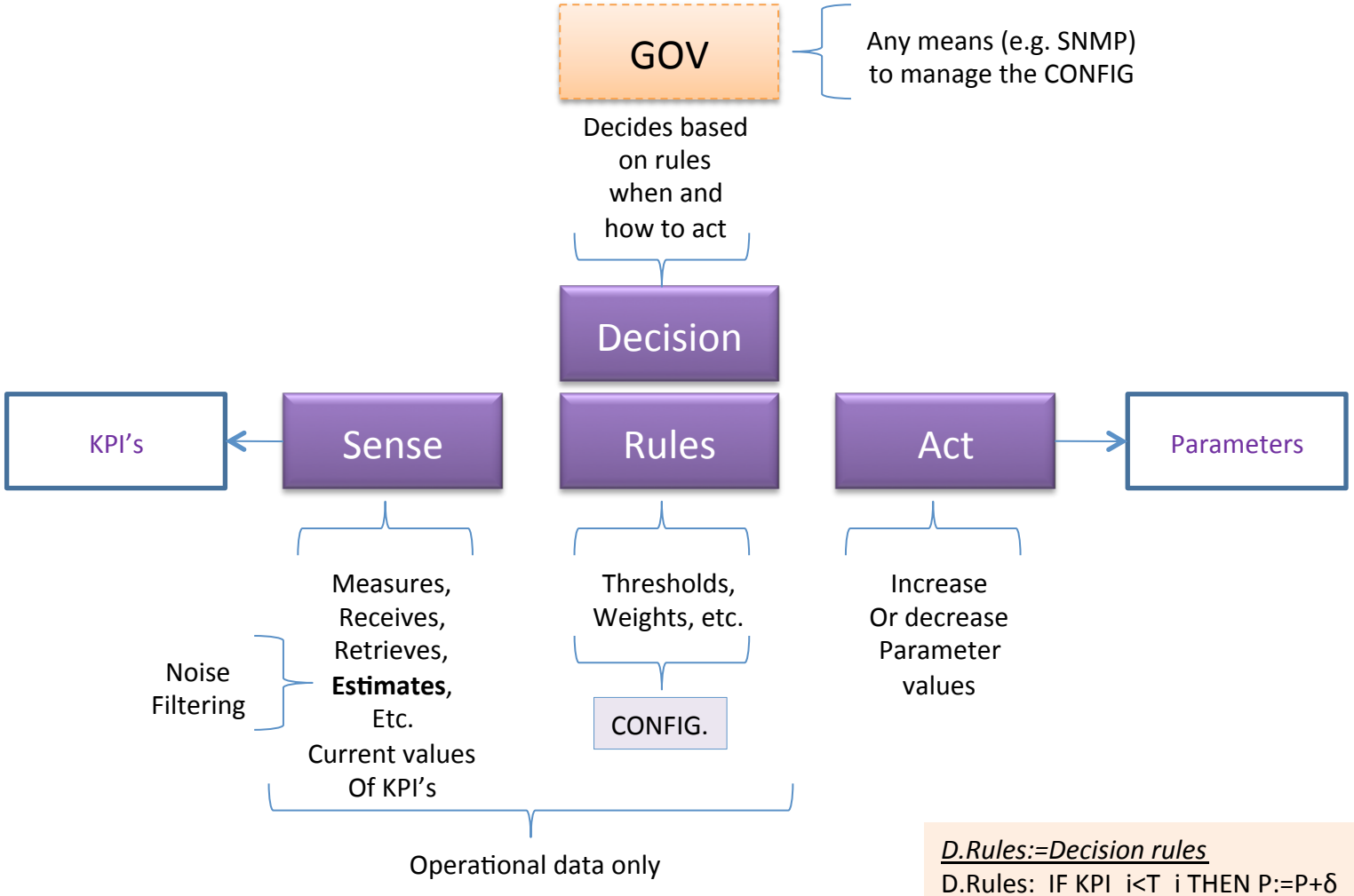
1 – Trustworthy interworking of NEMs in a Team

- 1.0: Orchestrated Team work with maximal utility
- 1.1: …with sharing of relevant context changes
- 1.2: …with sharing of relevant predictions

2 – Seamless Deployment of NEMs, NEM Teams

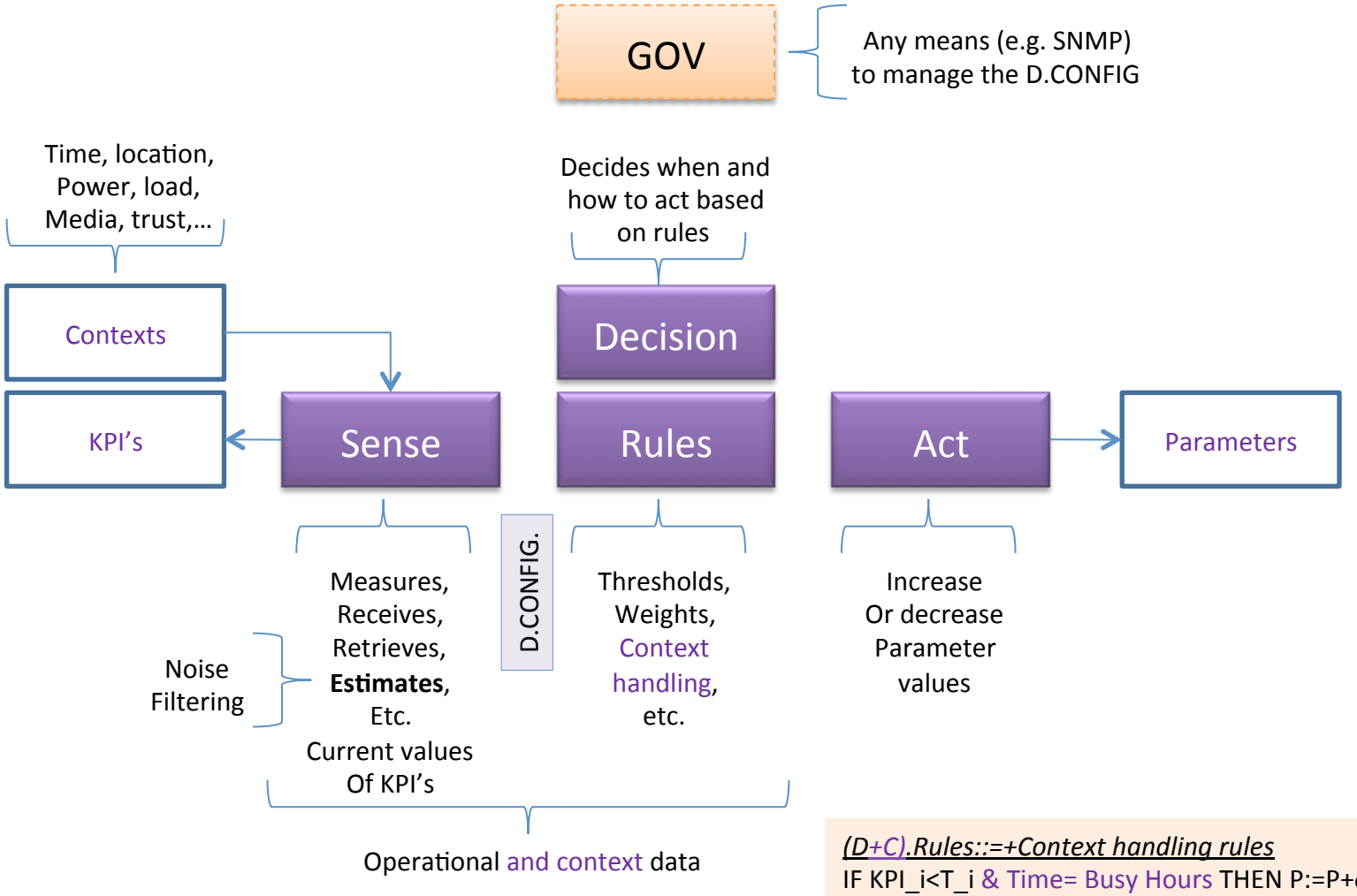
- 2.0: NEM/NEM Team Lifecycle Management
- 2.1: …with governed context sharing
- 2.2: … with governed knowledge building

UMF IN A NUTSHELL
CAPABILITY LEVEL 0.0



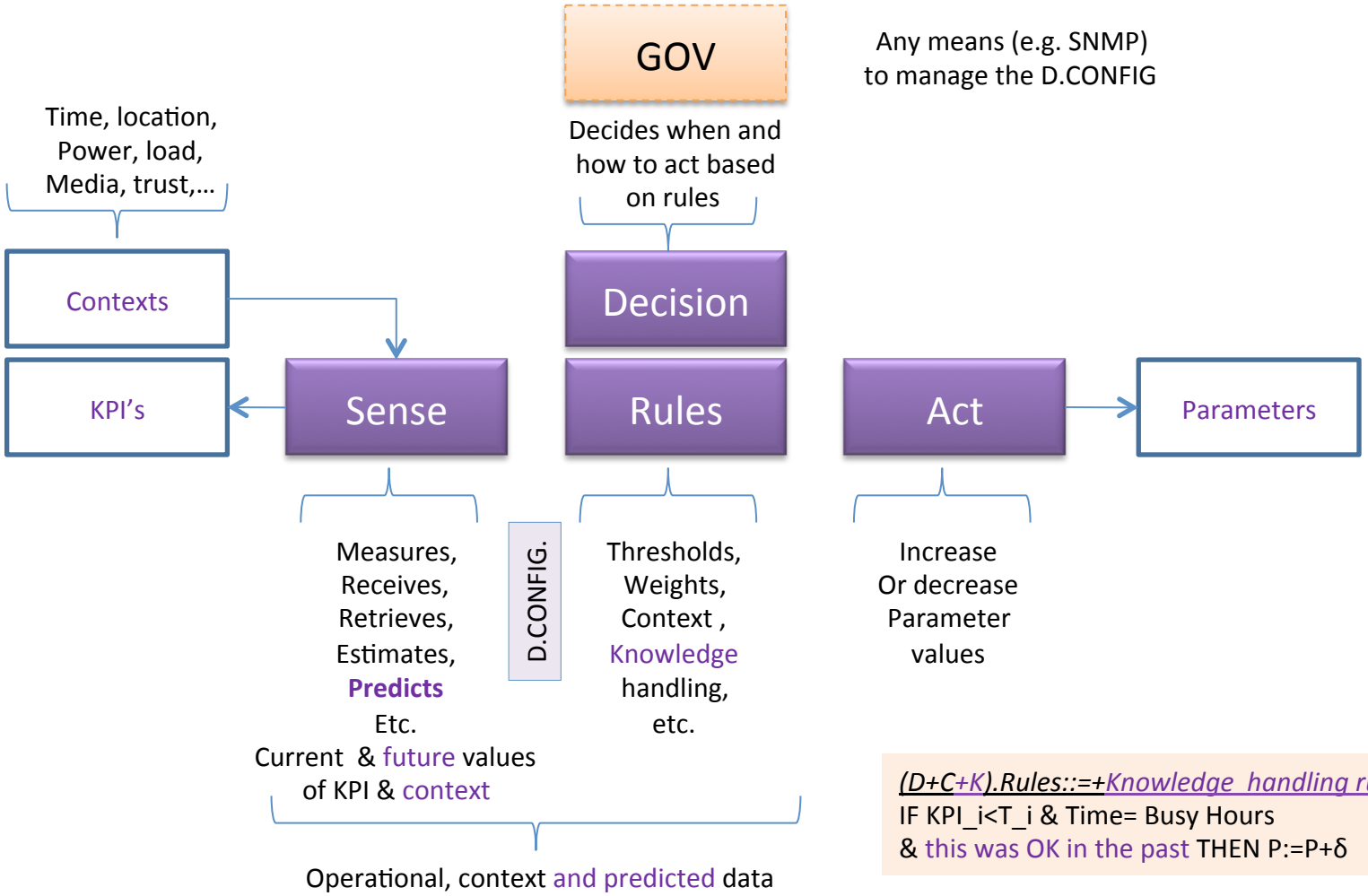
D.Rules:=Decision rules
D.Rules: IF KPI_i<T_i THEN P:=P+δ

UMF IN A NUTSHELL
CAPABILITY LEVEL 0.1



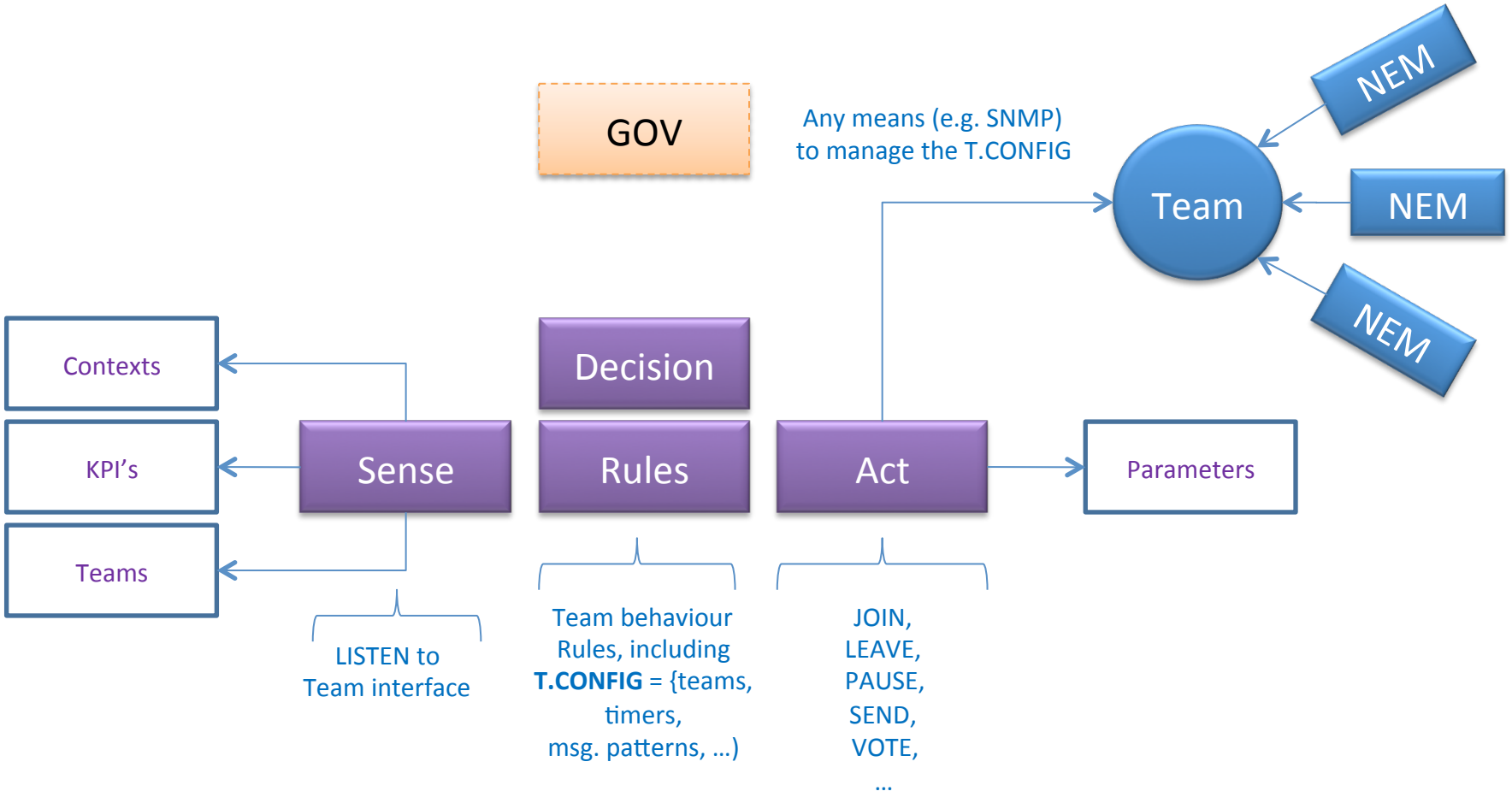
(D+C).Rules::=+Context handling rules
IF KPI_i<T_i & Time= Busy Hours THEN P:=P+δ

UMF IN A NUTSHELL
CAPABILITY LEVEL 0.2



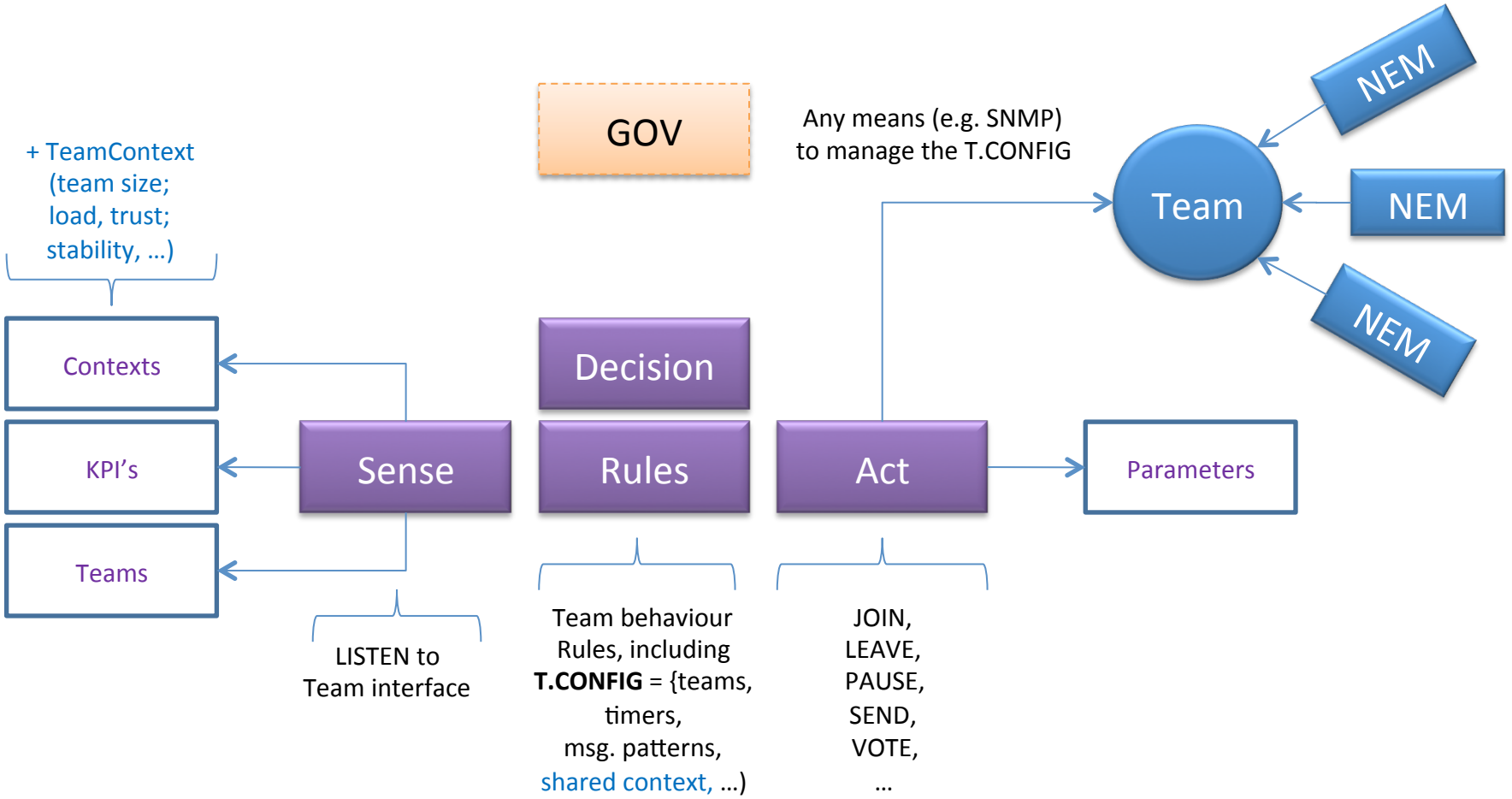
(D+C+K).Rules::=+Knowledge handling rules
IF KPI_i<T_i & Time= Busy Hours
& this was OK in the past THEN P:=P+δ

UMF IN A NUTSHELL
CAPABILITY LEVEL 1.0



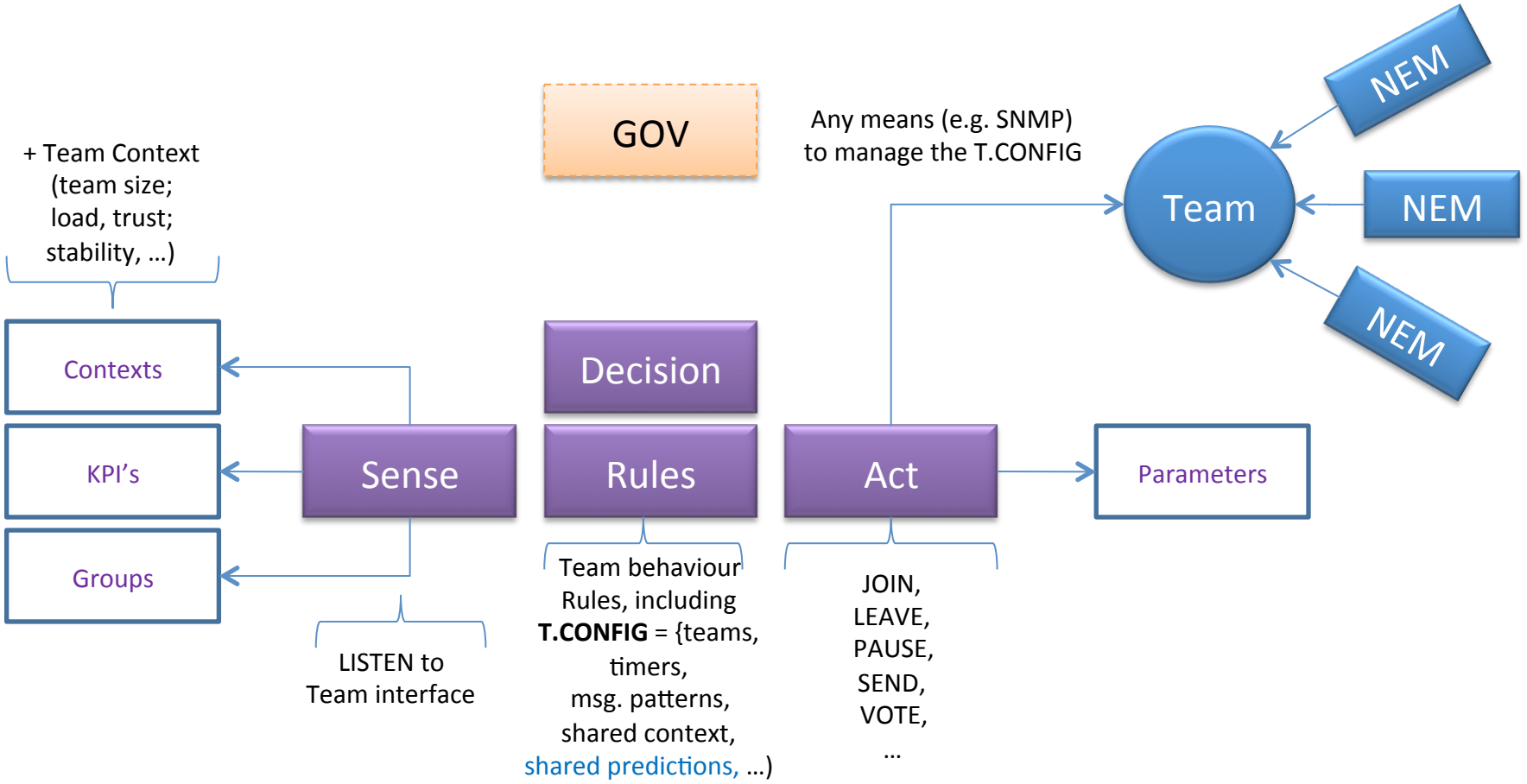
(D).T.Rules:=Decision-in-Group rules
IF KPI_i<T_i & Promised Utility Increase is the Highest in the Team THEN P:=P+δ
T.Rules:=Team Behaviour Rules
On BOOT send JOIN(TEAM*);
IF Time=Period & KPI_i<T_i THEN SEND(TEAM*, Utility_Promise), etc.

UMF IN A NUTSHELL
CAPABILITY LEVEL 1.1



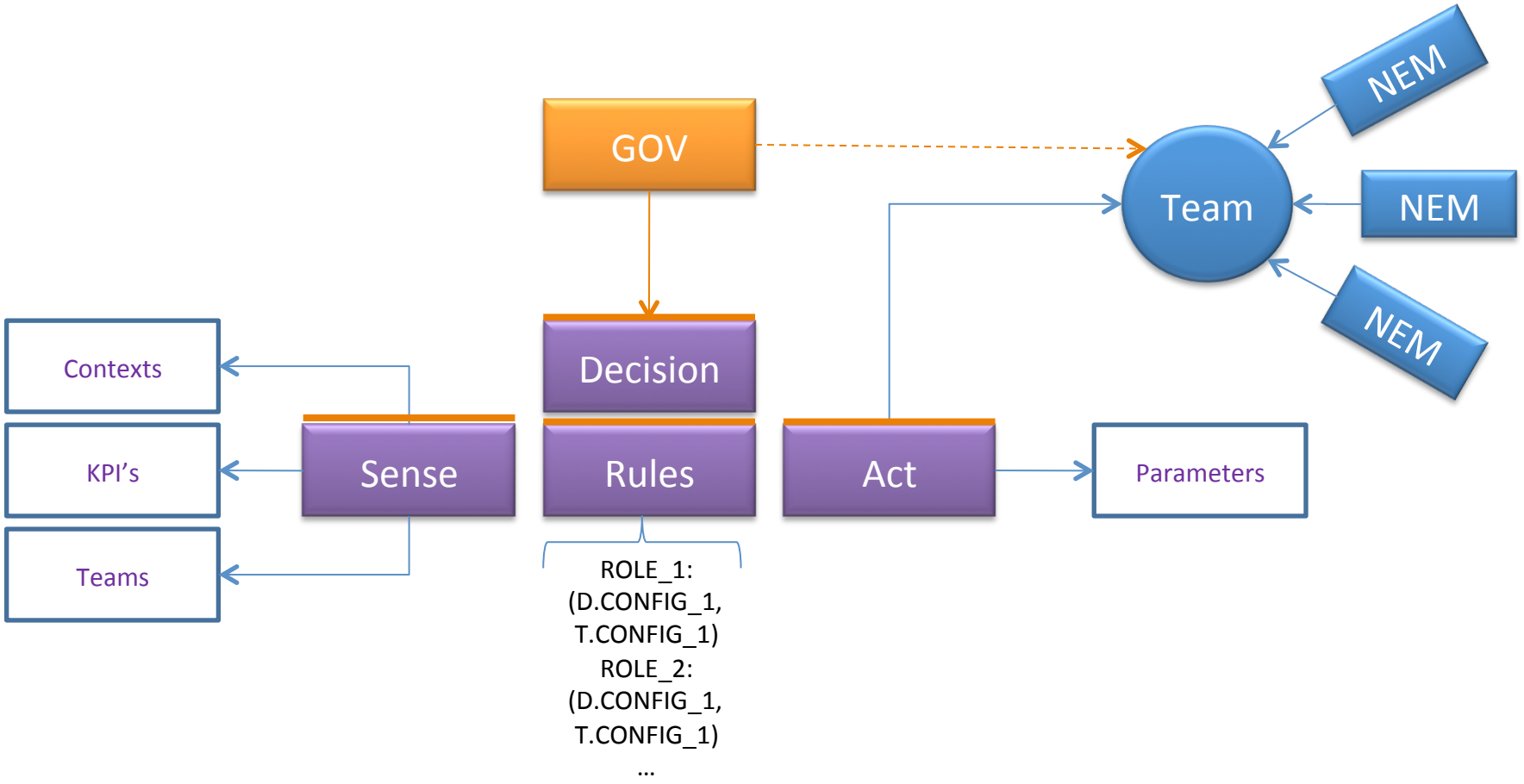
(D).(T+C).Rules:=Decision-in-Team rules
IF KPI_i<T_i & Promised Utility Increase is the Highest in the Team & Ctxt=Allowed THEN P:=P+δ
(T+C).Rules:=Team Behaviour Rules
On BOOT send JOIN(TEAM*);
On Ctxt_Change SEND(TEAM*, Ctxt_Change);
IF Time=Period & KPI_i<T_i THEN SEND(TEAM*, Utility_Promise), etc.

UMF IN A NUTSHELL
CAPABILITY LEVEL 1.2



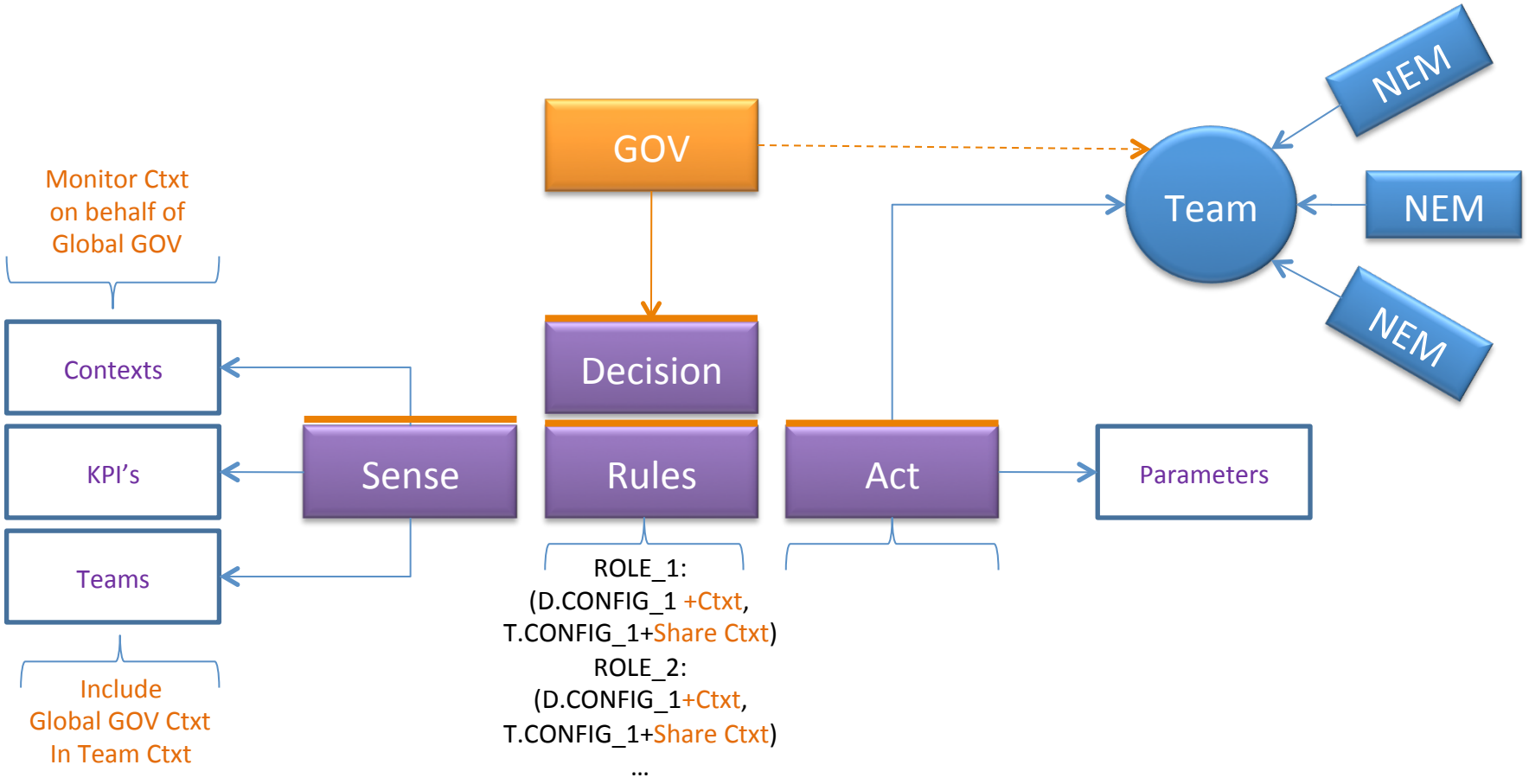
(D).(T+C+K).Rules:=Decision-in-Team rules
IF KPI_i<T_i & Predicted Utility Increase is the Highest in the Team & Ctxt=Allowed THEN P:=P+δ
(T+C+K).Rules:=Team Behaviour Rules
On BOOT send JOIN(TEAM*);
On Ctxt_Change SEND(TEAM*, Ctxt_Change);
On PredictedUtility>Threshold SEND(TEAM*, PredictedUtility);
IF Time=Period & KPI_i<T_i THEN SEND(TEAM*, Utility_Promise), etc.

UMF IN A NUTSHELL
CAPABILITY LEVEL 2.0



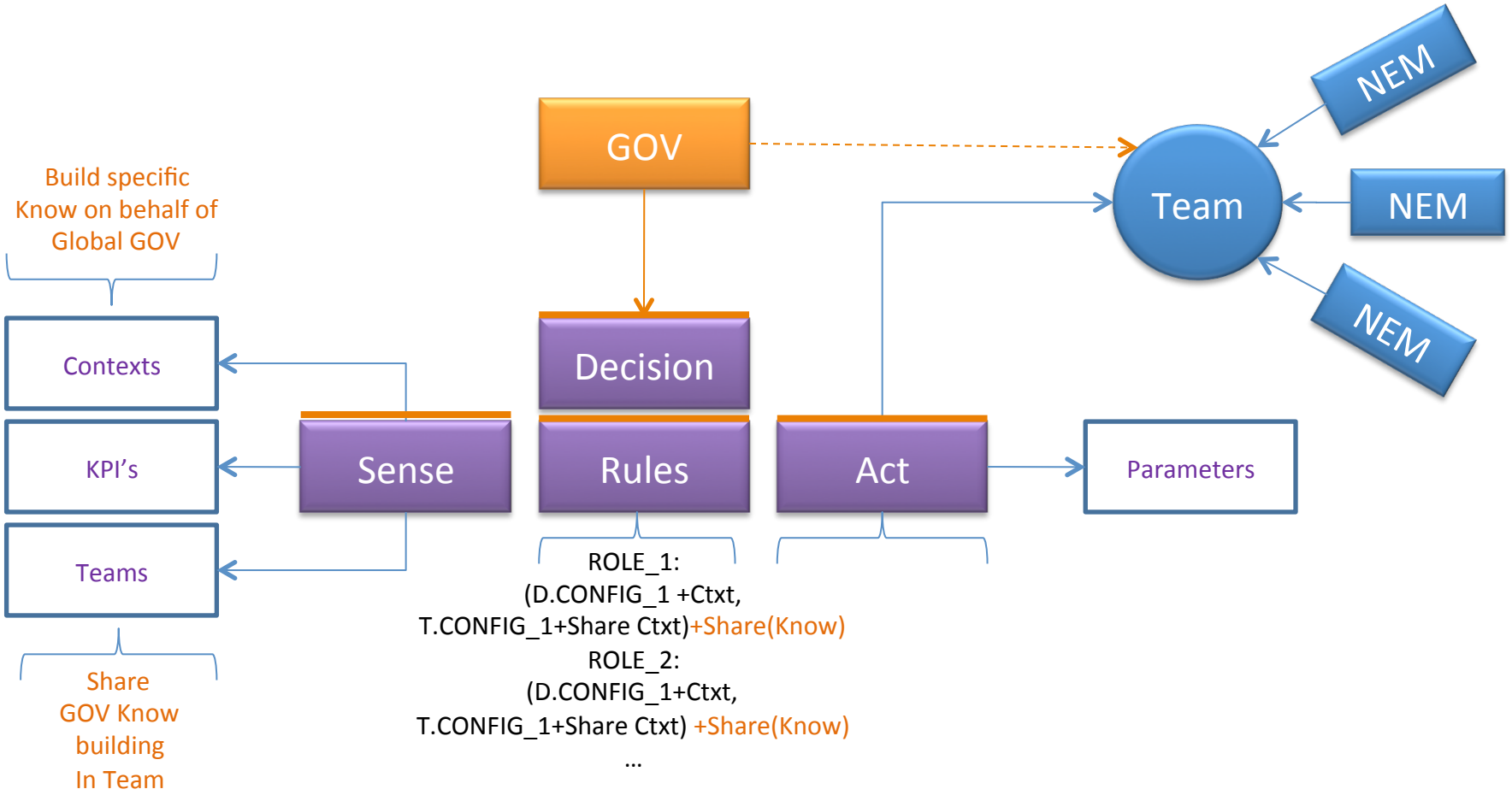
(D).T.G.Rules:=Decision-in-Group under Governance rules
On ROLE_1: (=Team Leader) On JOIN: SEND(Team*, Status), …
G.Rules:=Governance Rules
GOV-NEM: START(NEM), START(Team); STOP(NEM), STOP(Team),
REGISTER, ASSIGN_ROLE(), …

UMF IN A NUTSHELL
CAPABILITY LEVEL 2.1

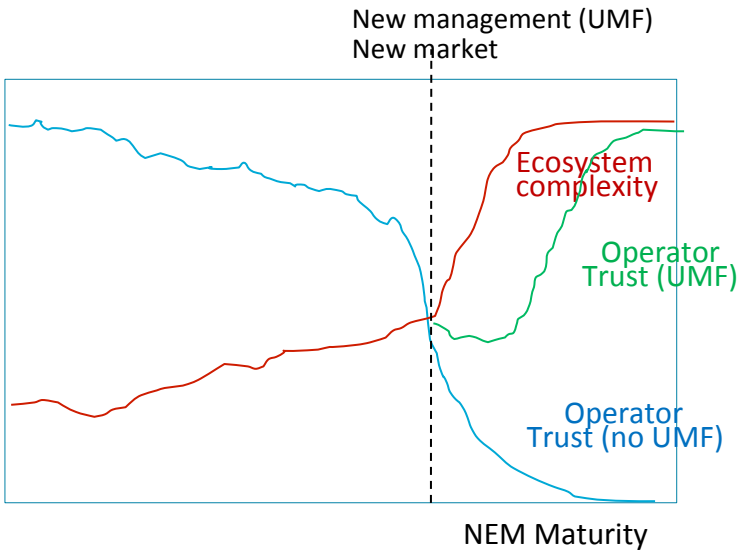


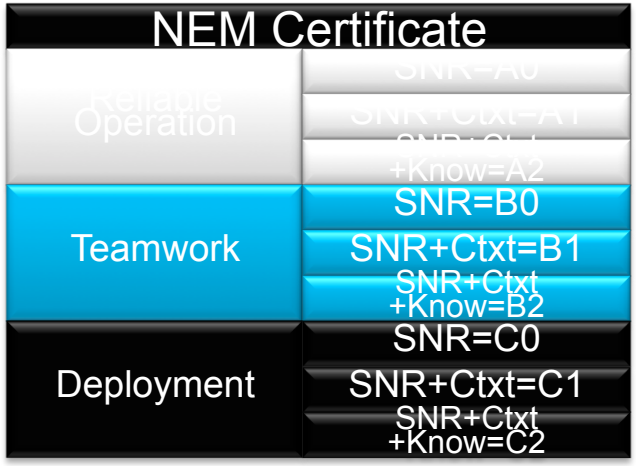
(D).(T).(G+C).Rules:=Decision-in-Group under Governance rules
On ROLE_1: (=Team Leader) On JOIN: SEND(Team*, Status), …, On WATCH(Ctxt): SEND(Team*, Ctxt:=Relevant);
(G+C).Rules:=Governance Rules
GOV-NEM: START(NEM), START(Team); STOP(NEM), STOP(Team),
REGISTER, ASSIGN_ROLE(), WATCH (Context), STOPWATCH (Context), …

UMF IN A NUTSHELL
CAPABILITY LEVEL 2.2



(D).(T).(G+C+K).Rules:=Decision-in-Group under Governance rules
On ROLE_1: (=Team Leader) On JOIN: SEND(Team*, Status), …, On WATCH(Ctxt): SEND(Team*, Ctxt:=Relevant);
On BUILD(Know): SEND(Team*, Build(Know));
(G+C+K).Rules:=Governance Rules
GOV-NEM: START(NEM), START(Team); STOP(NEM), STOP(Team)
REGISTER, ASSIGN_ROLE(), WATCH (Context), STOPWATCH (Context), BUILD(Knowledge), STOPBUILD(Knowledge), …





Components of a Message

- Objective: **Trust in Autonomics**
- Audience: **Operators**
- Technology: **P+SL+A**
- Impact: **Certification**

- 0 – Reliable operation of a standalone NEM
  - 0.1: Reliable decision making under noise
  - 0.2: … with context awareness
  - 0.3: … with prediction

Problem being solved by a NEM

- 1 – Trustworthy interworking of NEMs in a Team
  - 1.0: Orchestrated Team work with maximal utility
  - 1.1: …with sharing of relevant context changes
  - 1.2: …with sharing of relevant predictions

Problem being solved by a NEM group (ecosystem)

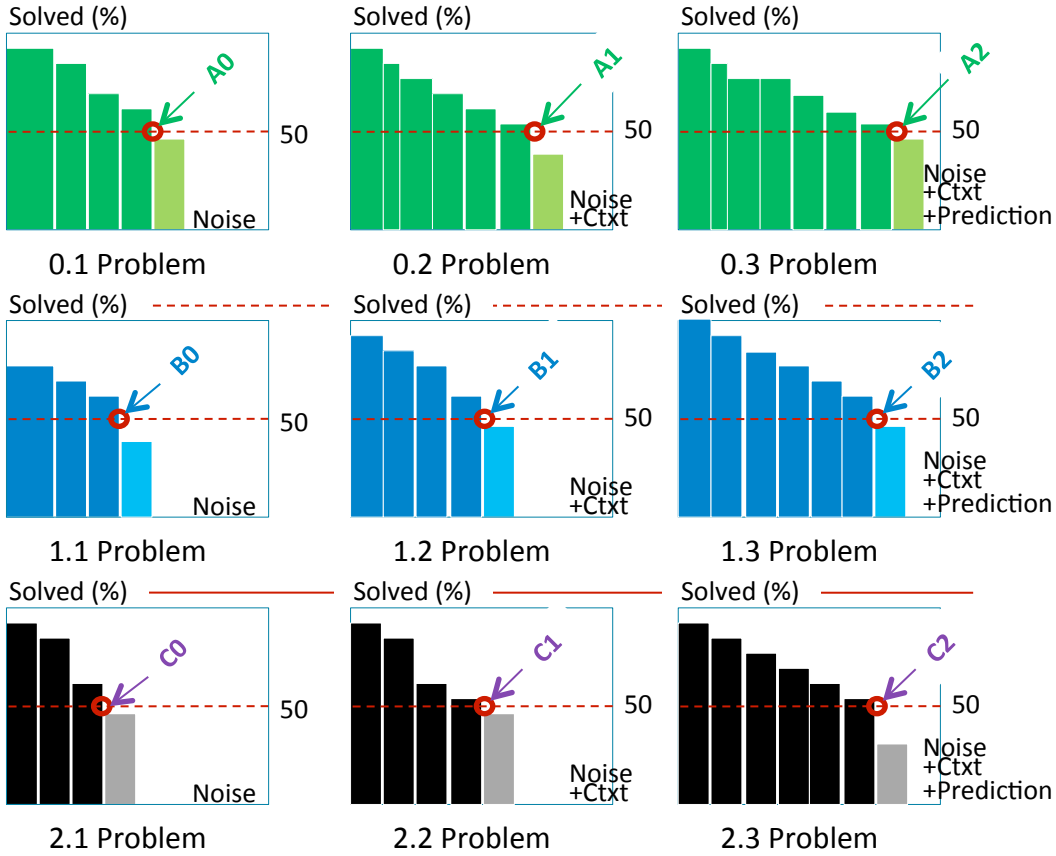
- 2 – Seamless Deployment of NEMs, NEM Teams
  - 2.0: NEM/NEM Team Lifecycle Management
  - 2.1: …with governed context sharing
  - 2.2: … with governed knowledge building

Problem being solved by a UMF+NEM group (ecosystem)

NEM Maturity

Sophistication of existing market

New market



Technology: **Predicates + Subjective Logic + Assessment**

Capability=2:+ROLE a set of connected behaviours, rights and obligations as conceptualised by actors in a network situation

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