TACTICS

Protecting Tactical Service Oriented Architectures

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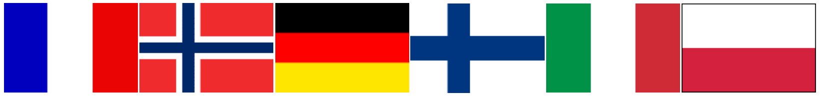
TACTICS consortium consists of 12 members and subcontractors, while the projects studies will*

- **Propose the definition of a service-oriented architecture (SOA) compatible with the constraints of tactical radio networks.**
- **Suggest feasible ways of adapting services to the constraints of the tactical radio networks.**
- **Demonstrate the capacity of a Tactical Service Infrastructure to offer operational services in a real tactical environment.**



(*TACTICal Service oriented architecture, Proposal for EDA ad hoc B Program)

The role of NTNU in TACTICS security

- Monitor and advice on security related aspects/ requirements
- Secure cross-layer network capabilities
- Secure protocols and algorithms for robust distributed service storage, retrieval, and discovery
- Secure, efficient and robust overlay routing with the incorporation of cross-layer information
- Necessary enhancements for the optimised performance of routing and QoS mechanisms
- Investigation of protection goals and requirements for tactical SOA
- Robust and adaptable security policies for tactical SOA
- Lightweight and dynamic protection mechanisms
- Information filtering, classification and provenance assurance

NTNU
Norwegian University of Science and Technology

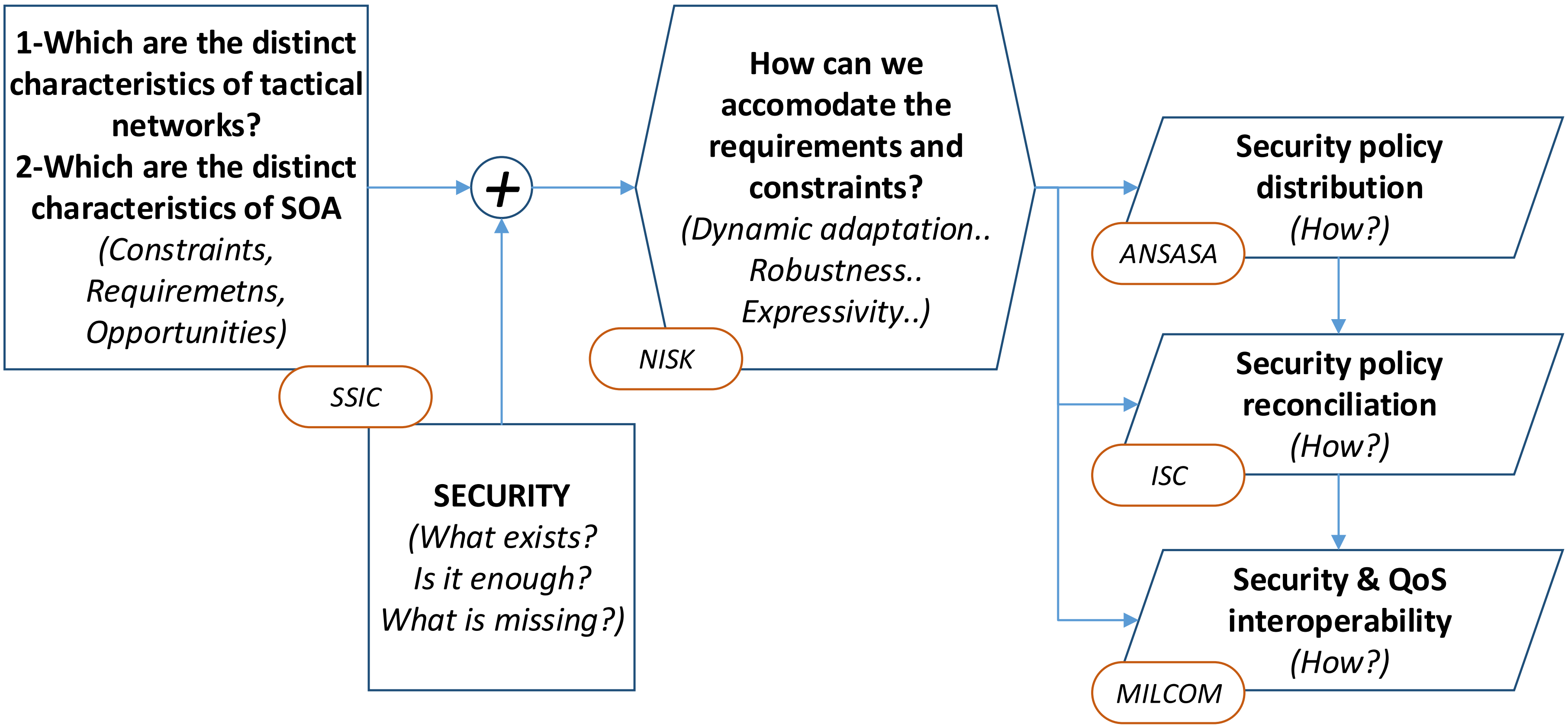
(*TACTICal Service oriented architecture – Partners Contributions, Proposal for EDA ad hoc B Program)

Mutatis mutandis: From contribution to research question

- **Investigation of protection goals and requirements for tactical SOA**
- **Robust and adaptable security policies for tactical SOA**
- **Lightweight and dynamic protection mechanisms**

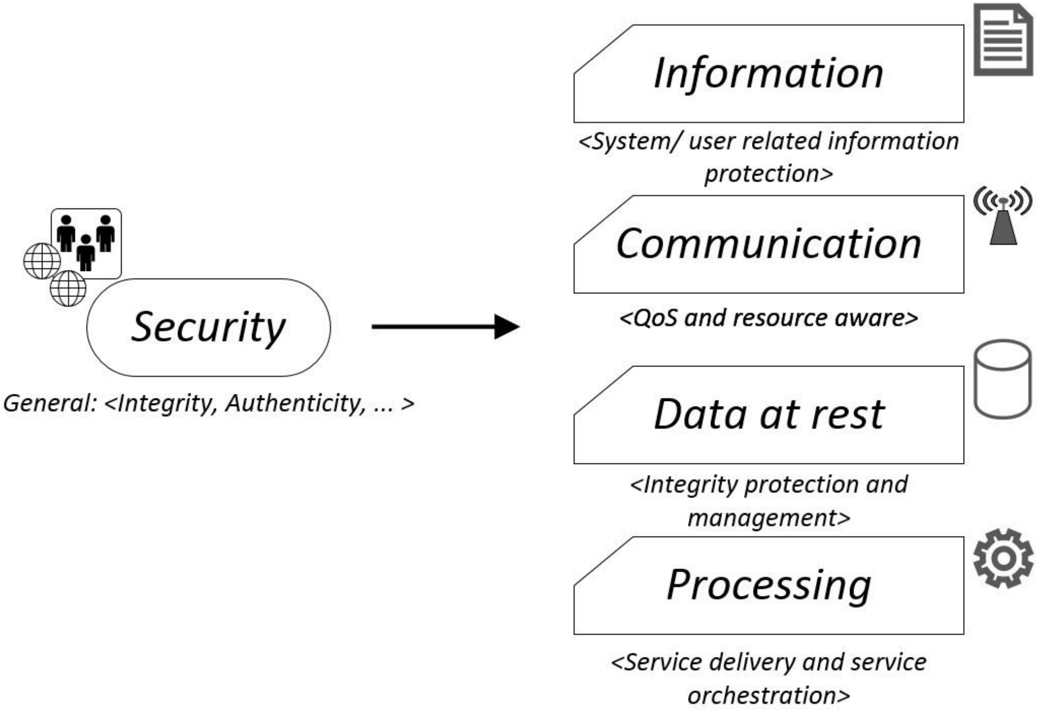
➢ ***How can a security policy that is sufficiently expressive to allow the incorporation of discretionary access control equivalent to restricted access matrices and label-based mandatory access control, be formulated in such a way that the policy and its computations can be distributed across a set of nodes in a distributed system with intermittent connectivity, yet remain consistent?***

Protecting tactical service oriented architectures



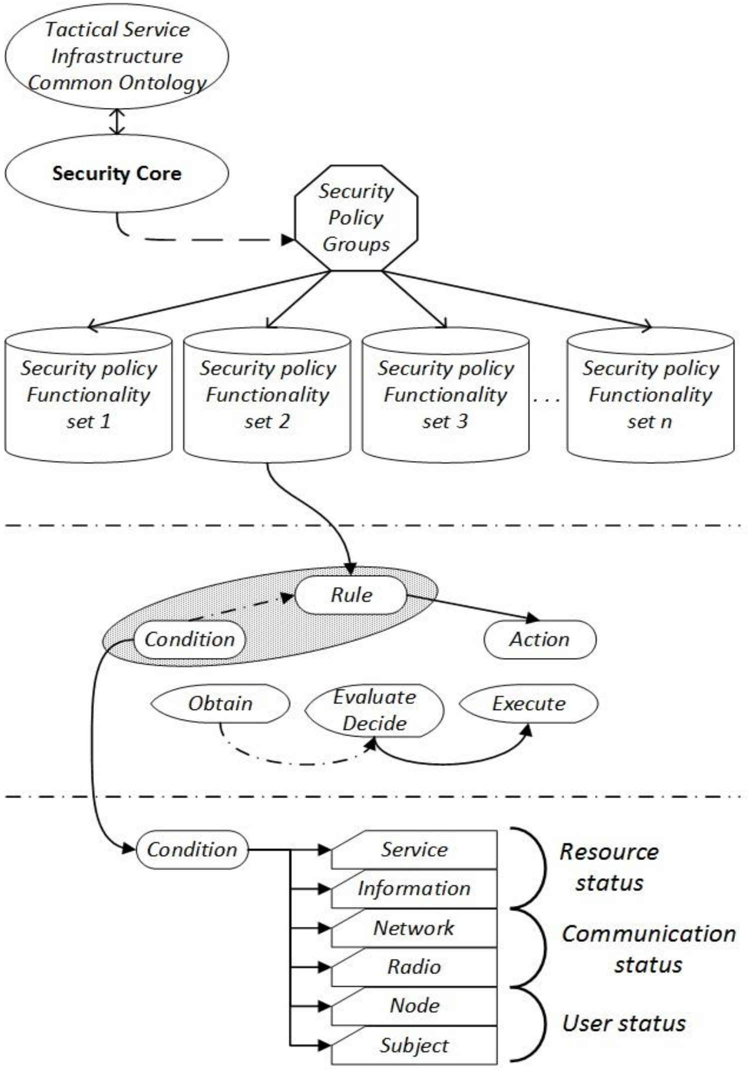
- **Node limitations**
  - Transmission/ Reception range
  - Input/Output limitations
  - Power consumption
  - Physical limitations
  - Environmental conditions
  - Interconnection capabilities
  - Computational capacity
- **Network limitations**
  - Transmission disruptions
    - Due to radio range, interference (e.g. packet collisions, multipath transmission, jamming), physical obstacles, active attacks (e.g. wormhole, black-hole, denial of service)
  - Mobility
    - Due to dynamic network configurations (Referring both to routing and IP/ID planning and management), coalition operations, service delivery handover, multinetwork affiliation.
  - Communication
    - Due to scarcity of available radio resources (e.g. bandwidth, frequencies), protocols, and radio characteristics (e.g. packet error rate, jitter, delay)
  - Application layer
    - Due to service delivery, discovery and registry management.

- **Generic protection goals, similar to those found in other systems, such as:**
    - Confidentiality
    - Control
    - Integrity
    - Authenticity
    - Availability
    - Authentication
    - Authorization
    - Non Repudiation
    - Utility
    - Accountability
    - Trust
    - Traceability



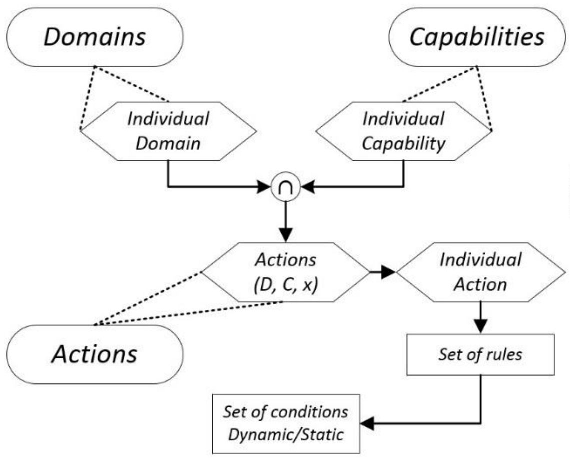
An initial form of the solution

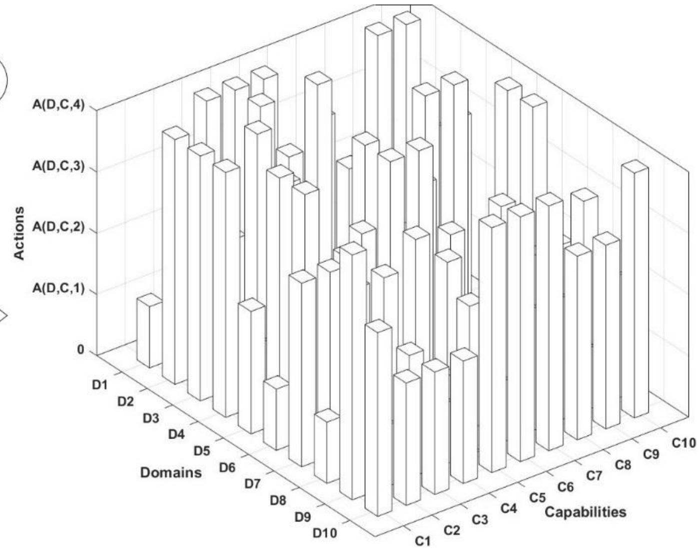
- **Incorporation of cross layer information originating from:**
  - Services
  - Data
  - Network
  - Radios
  - Terminals
  - Users



Security policy architecture, with OWL

- **Fine-grained conceptualization of constituent network elements**
- **Anticipated processes**
- **Operational requirements**





Individual_Domain ∩ Individual_Capability = {Individual Action A(k), Individual_Action_A(k+1), … , Individual_Action_A(k+ j)}

where

Individual_Action_A(k) ≈ Rule A[k(z)],Rule A[k(z+1)] , … , Rule A[k(z+i)]}

• Description logic (DL) fragments

- ALC + role hierarchies and inclusion, inversion, nominals, functionality properties and qualified cardinality restrictions – SHOIN(D)

$$Terminal \equiv individual \sqcap \exists has\_Terminal\_ID.\perp$$

$$Local\_Provider \equiv Terminal \sqcap \exists Has\_Operational\_Group.OG2 \\ \sqcap \exists Has\_Status.Online \sqcap \exists Has\_Functionality.SP$$

$$Available\_Service \equiv Service \sqcap \leq 1 Has\_Local\_Provider$$

$$\begin{array}{r} Concept\ assertion \\ File \sqcap Video(Message\_x) : Message\_x\ is\ a\ video\ file \\ Role\ assertion \\ hasSource(Message\_x, Terminal\_y) : Terminal\_y\ is\ the\ source\ of\ Message\_x \end{array}$$

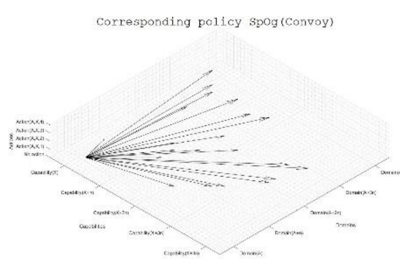
Why is policy distribution required?

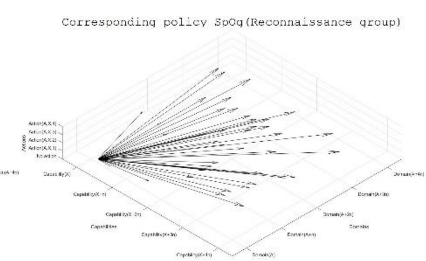
- **Diversity of node capabilities**
  - (Nodes can not be expected to be able to support all the security mechanisms)
    - Distinct platforms, with diverse capabilities and requirements
    - Dynamically adaptable policies are too heavyweight for some types of tactical nodes
- **Operational and functional diversity of deployed assets**
  - (Nodes are not required to support all the security mechanisms)
- **Dynamic network topologies**
  - (No centralized security dedicated entity can be assumed, due to constant alteration of the available resources and connectivity)

What effects the policy distribution?

- **Ontology (policy)**
  - Syntactic complexity
  - Structural complexity
- **Tactical nodes**
  - Operational specialization
  - Functional specialization
  - Operating features
- **Dynamism**
  - Dynamic attributes
  - Dynamic policy evaluation
  - Tactical decision cycle

- Action : $A'n = (D\hat{\imath} + C\hat{\jmath} + A\hat{g})$, Where $\hat{\imath}, \hat{\jmath}, \hat{g}$ *are unit vectors*
  - Security policy: $SpOg_{(x)} = \{V_i, V_{i+1}, \dots, V_{i+n}\}$
  - $SpOg_{(x)} = SpFg_{(j)} \cup SpFg_{(j+1)} \cup \cdots \cup SpFg_{(j+n)}$
  - $V_{(n)} = \{R_{(i),} R_{(i+1)}, \dots, R_{(i+n)}\}$
  - Vector complexity: $CV_{(n)} = \sum_{i=1}^{n} CR_{(i)}$
  - ...
  - Maximize: D= $\sum_{i=1}^{k} \sum_{j=1}^{n} pR_{(j)} * X_{ij}$
  - Subject to: $\sum_{j=1}^{n} CR_{(j)} * X_{ij} \leq CCFg_{(i)},\ i = [1, \dots, k]$
  - $\sum_{j=1}^{n} Xij = 1, i = [1, \dots, k]$
  - $Xij = 1 \; or \; 0, i = [1, \dots, k], j = [1, \dots, n]$
  - $Xij = \begin{cases} 1 \; if \; R_{(j)} \; is \; selected \; for \; Fg_{(i)} \\ 0 \; if \; not \end{cases}$





Types of divergences to be reconciled

- **Strict syntactic, terminological and semiotic homogeneity**
  - **(The distributed ontologies are consistent to the central model)**
    - -Conceptual heterogeneity
- **The local ontologies operate within only two dimensions of context dependent representation (Partiality and perspective)**
    - -Approximation is only utilized across the governing rules

- **Thus:**
  - **We face only conceptualization mismatches and differences in perspective**
  - **Explicitation mismatches, coverage differences and granularity differences will not occur**
  - **These changes will only occur on data and object properties**
  - **The only allowed alterations are modifications**
  - **Extensions and reductions are not allowed**

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Additional limitations

- **Ontology mapping is mature…**
  - **but what about communication constraints?**
    - Cannot transmit the entire local ontology
    - Cannot include multi-transaction negotiation methods
    - Cannot depend on a centralized entity
    - Must limit the number of involved nodes
    - Increased reconciliation confidence is required
    - Must maintain history of updates
    - Roll back capability is required

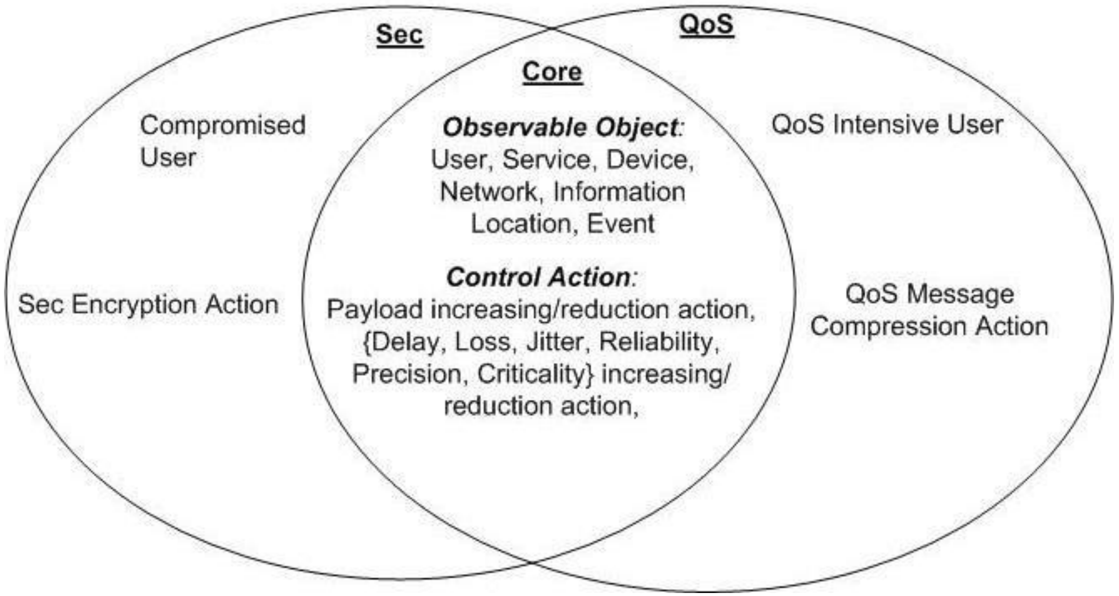
- **Local ontology**
  - Fragment of global policy
- **Local node assignment list**
  - Fragment of global node assignment list, responsible for the identification of the subset of nodes, which incorporate the altered element.
- **Local change ontology**
  - Maintains a copy of locally sensed and enforced changes for audit and roll back purposes
- **Criticality/ timeliness measure**
  - For prioritization purposes
- **Archive of requested changes**
  - Maintains a copy of externally requested changes for audit and roll back purposes
- **Δ**
  - It includes the altered element, and various characteristics of the alteration, such as justification, time, actor.

Security and QoS interoperability

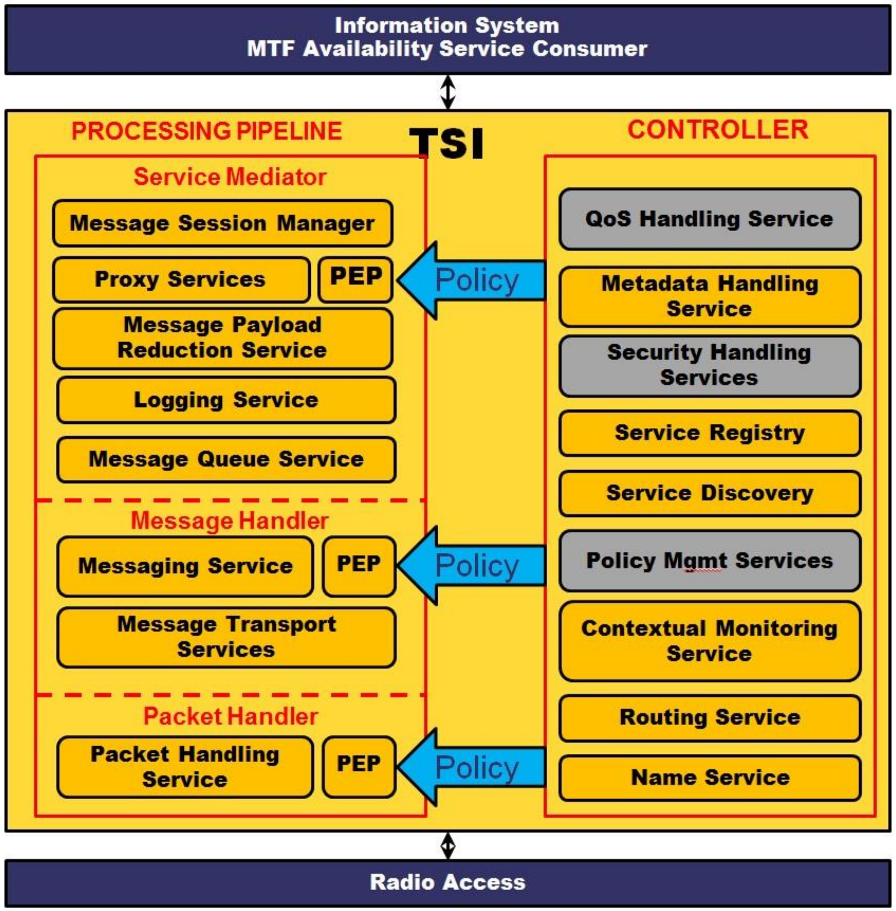
- **Security related considerations**
  - Enforcement of protection goals (under the aforementioned constraints)
- **QoS related considerations**
  - Message encapsulation and processing, down to the level of packets sent over radio, has been carefully adjusted across the TSI stack before radio emission.
  - ✓ Messages of higher priority/reliability will always receive prioritized treatment.
  - ✓ Messages temporized or degraded should be dealt with appropriately.
  - Etc (traffic management, battery consumption …)

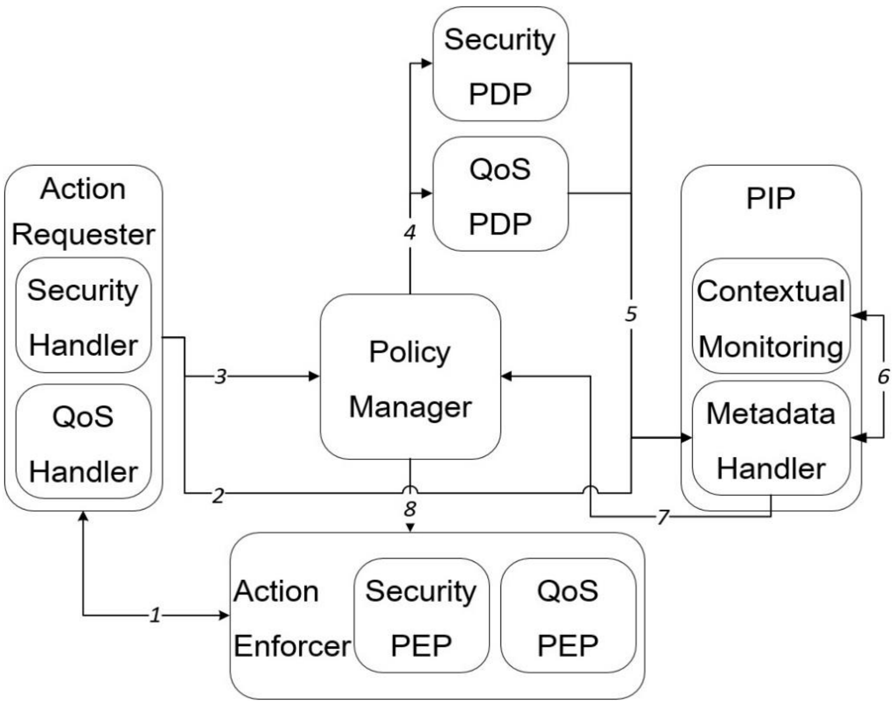
Proposed solution

- **Ontology and policy framework adjusted to TACTICS**
  - Observable objects
    - Static and dynamic attributes both in raw, aggregated or statistical form
  - Enforcement mechanisms
    - Session manager, service registry, encryption, message adaptation etc
  - Actions
    - Prioritise service invocation, drop message, isolate compromised node etc.



- **Interoperability mechanism**
  - Based on TACTICS architecture and Tactical Service Infrastructure.





Thank you

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