Assessing the Security of Internet Connected Critical Infrastructures

The Comifin Project Approach

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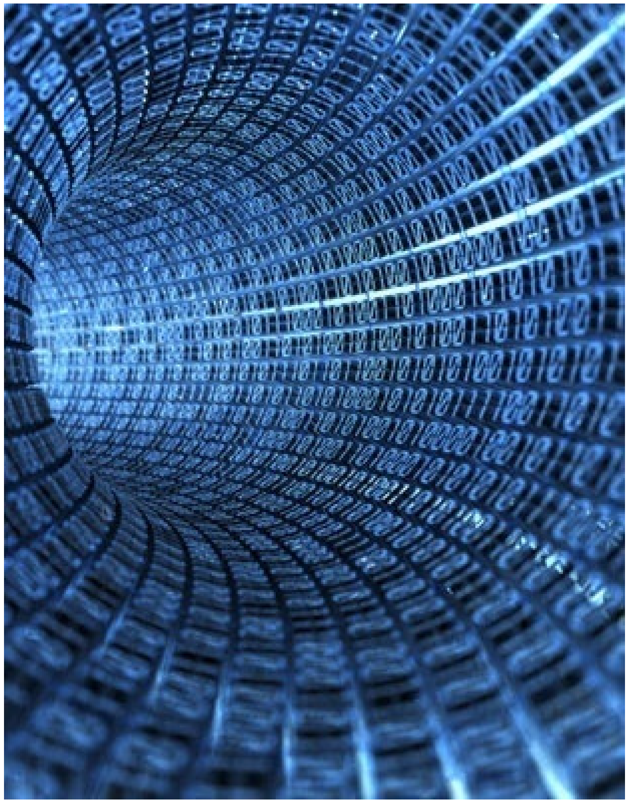
Motivation

- ❑ IoT ='s data conduit linking "things"
- ❑ Things … sensors, devices, systems …. and onto comm. links within and across Critical Infrastructures (CI) for sensing, notification and control

➔ IoT resilience (or its lack) affects the CI resilience based on it



Goal: Basing Secure Communications on Insecure IoT

- ❑ Overlays
  - Adds filters
  - Adds routes
  - Adds functionality
  - ➢ Provides buffer to IoT threats ➔ Decouples IoT and CI associations
  - ➢ Provides monitoring of IoT <-> CI

- ❑ P2P etc : Classical approaches offer use of redundant paths and resources…but mostly offers regulated levels of resilience
  - Resources change, routes change
  - Attacks change

➢ Can we enhance IoT-centric overlays based communication to a "metrics" driven <u>adaptive</u> (on-demand QoP) levels of resilience?

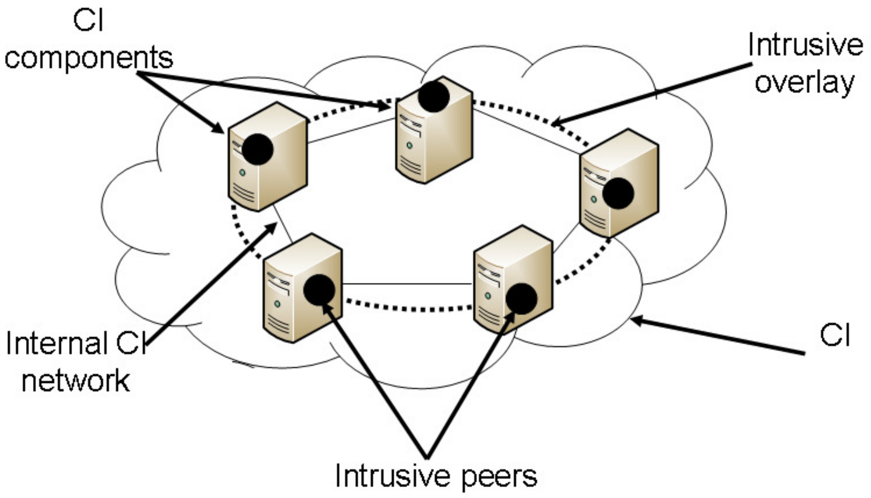
Approach: Metrics Driven Adaptation

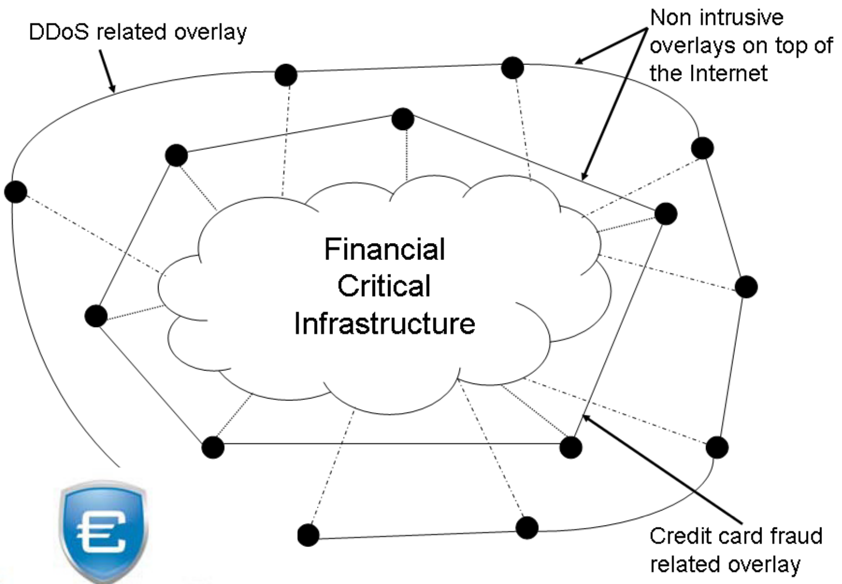
- ❑ Quantify resilience of IoT (sensing and communication) overlays
  - Overlay trust metrics
  - QoP specification with CI application-relevant metrics
- ❑ Utilize the metrics basis to provide adaptation of overlays QoP
  - Design phase (Trustworthiness by Design)
  - Run-time phase (Trustworthiness by Adaptation)

Process

- ❑ Metrics-based scoping of SLAs
- ❑ (Automated) Generation of the monitoring configuration from the metric and SLA definitions
- ❑ Multi-level metric evaluation system to handle complexity utilizing
  - simple arithmetic evaluators
  - simple rule based evaluator
  - complex event processing based evaluator
- ❑ Reference implementation for trustworthiness by adaptation based on run-time metrics monitoring
  - Case Study: P2P-based protection approaches targeting a Financial Infrastructure (FI)

IoT linked CIP Overlay Models (Intrusive, Non-Intrusive)




DDoS related overlay
Non intrusive overlays on top of the Internet
Financial Critical Infrastructure
Credit card fraud related overlay

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- ❑ Intrusive Overlays: Dedicated probes, routers, channels …
- ❑ Distributed control systems (SCADA)

- ❑ Non-intrusive Overlays … e.g. P2P: self standing properties - secure, dependable - & decoupled from the CI!
- ❑ CI handled as black-box
- ❑ Non-intrusive approach to realize an additional defense line/layer that implements further/new (usually collaborative) security mechanisms

Trustworthiness Metrics

- Determining appropriate set of metrics requires extensive understanding of the target domain (Savola taxonomy)
  - RoI cost-benefit metrics
  - ISM information security management metrics
  - SDT security, dependability & trust metrics

  ➔ GQM: Goal-Question-Metric (user centric)

- **CoMiFin**: multi-level GQM based evaluation system containing
  - Resource-level metrics: CPU, sensor, net usage
  - Availability metrics: uptime, availability, repair time
  - Communication metrics: encryption strength, latency
  - Overlay specific metrics: k-connectivity etc
  - CI Application SpecificTrust metrics:
    - CI application requirements, responsiveness, quality, privacy, …
    - Trust level of participant CI entity, type/priority of shareable info

Metrics Driven QoP Assessment

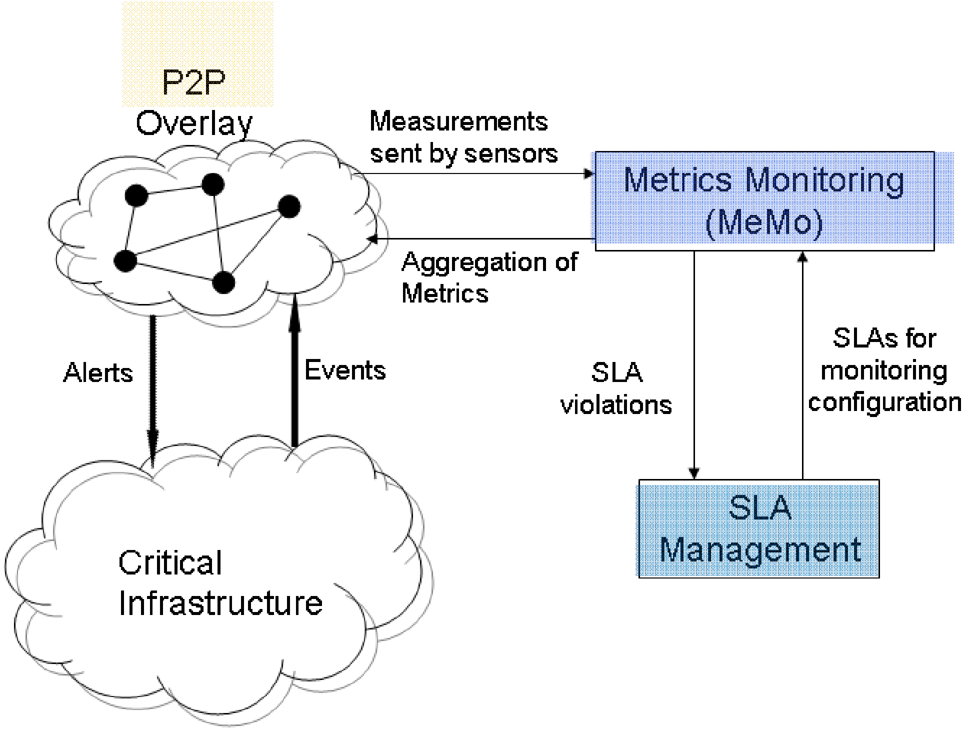
By Design　　　　By Adaptation

- ❑ Application dependent overlay security requirements
- ❑ Metrics set to monitor fulfillment of requirements

- ❑ Usage of metrics for SLA specifications with viability of run-time monitoring (MeMo: Metrics Monitoring)
- ❑ IoT based compliance monitoring on SLA "degree of compliance"
- ❑ SLA violation detection with SLA "adjustments" framework

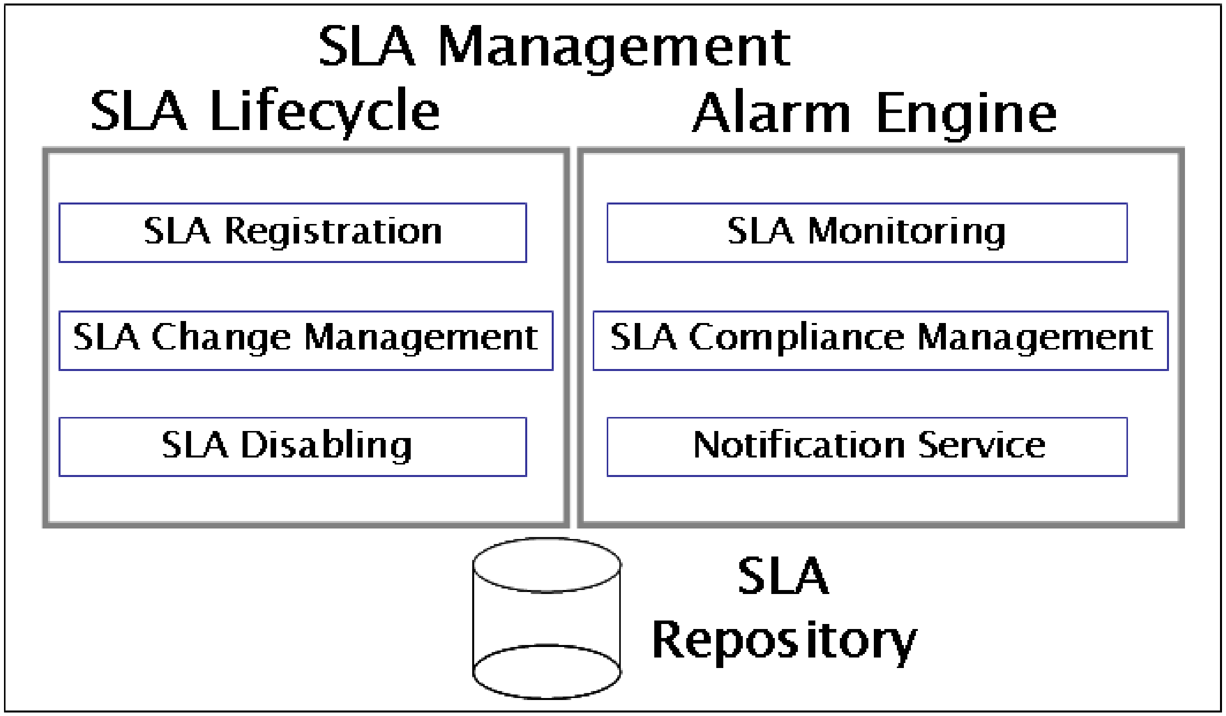
Metric-based QoP Assessment

- Core ideas
  - Metric-based definition of SLAs
  - Run-time metric monitoring & SLA compliance checking



Trustworthiness by Design

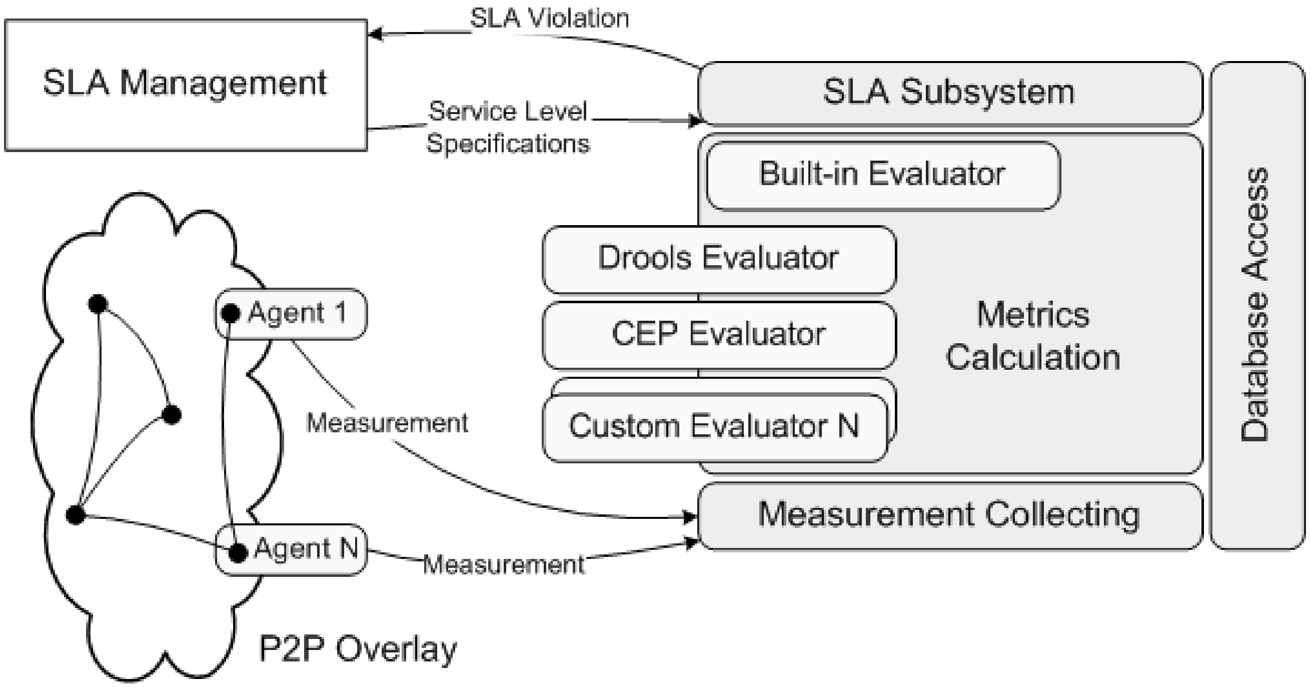
- ❑ Define metric-based SLA to
  - capture user requirements
  - specify guarantees the system is required to provide
  - define penalties for missing specified guarantees
- ❑ Implementation of an SLA Management component



Trustworthiness by Adaptation

Goal: evaluate QoP at run-time and accordingly trigger alerts or overlay reconfigurations to maintain the desired QoP level

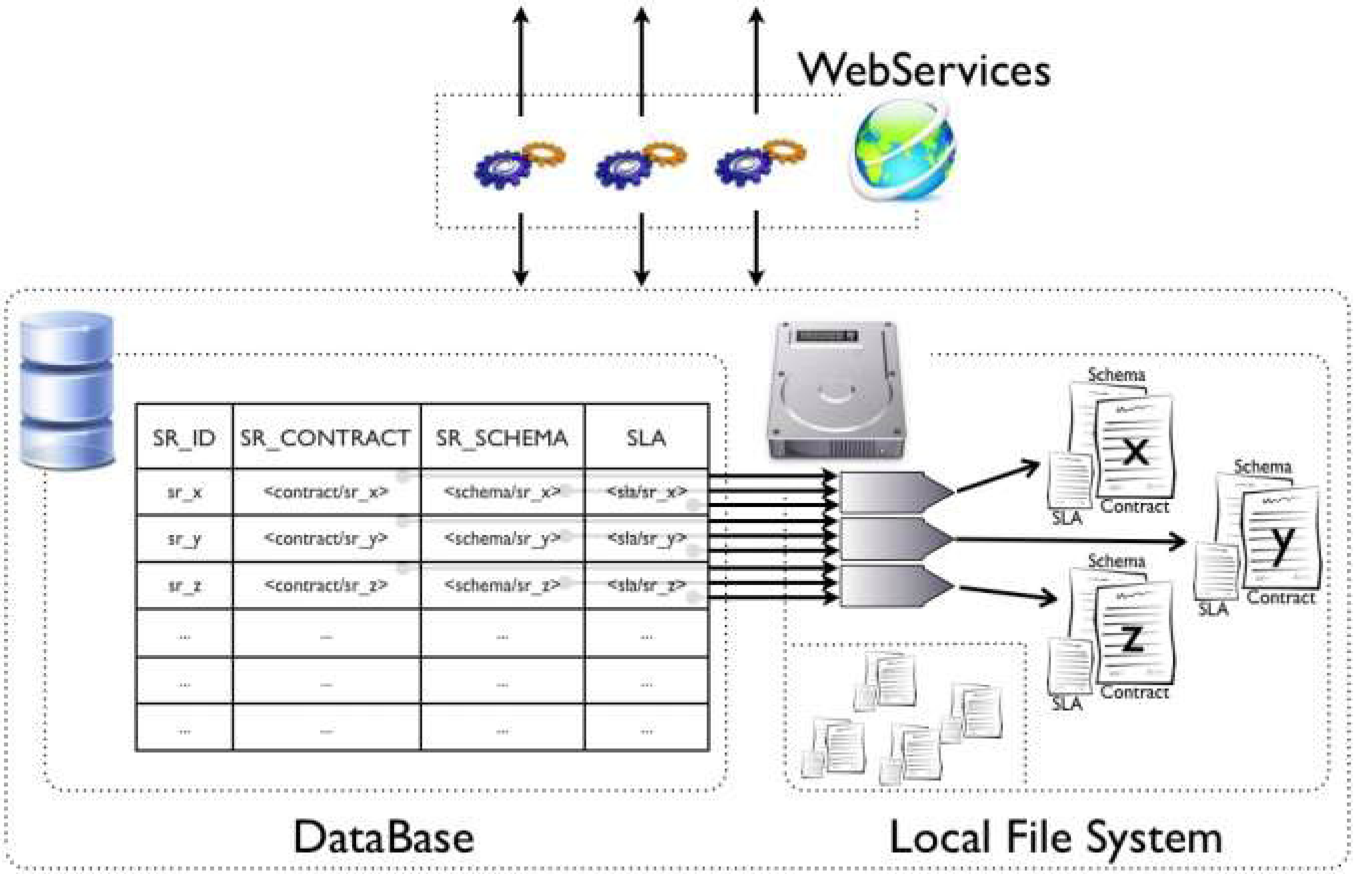
- ❑ Metrics Monitoring (MeMo) approach
  - collects run-time measurements (Drools rule engine)
  - calculates trust metrics (CEP Evaluator – IBM Agilis etc)
  - notifies on SLA violations



Status: Trustworthiness by Adaptation

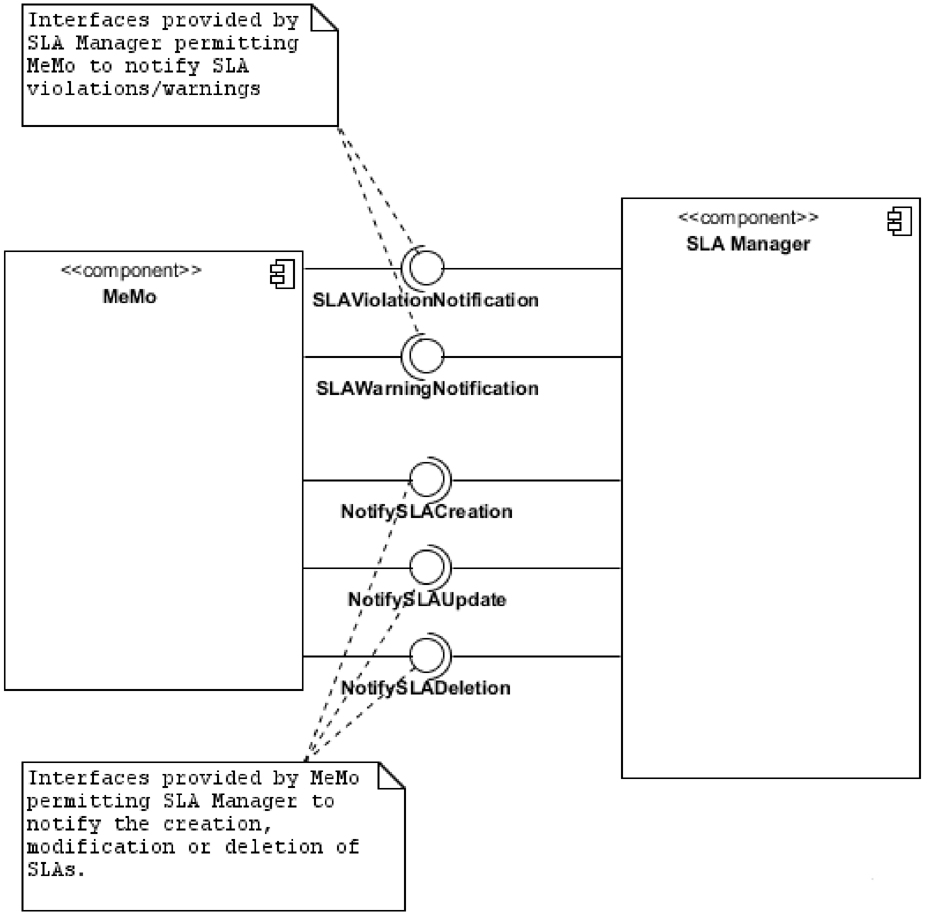
- ❑ Automated Generation of Monitoring Configurations:
  - IoT infrastructures are subject to frequent changes
  - Consistent and coherent model of the system needs to be maintained
  - Forms basis of IT system monitoring and management
- ❑ SLA Manager interacting with MeMo to monitor the degree of compliance with predefined SLAs
- ❑ Interaction with MeMo triggered on FI SLA violations
- ❑ IoT-based monitoring activities of MeMo for detection of SLA violations for reporting & adaptatation to SLA Manager
- ❑ Countermeasure detailing as per penalties stated in the SLA

SLA Generator

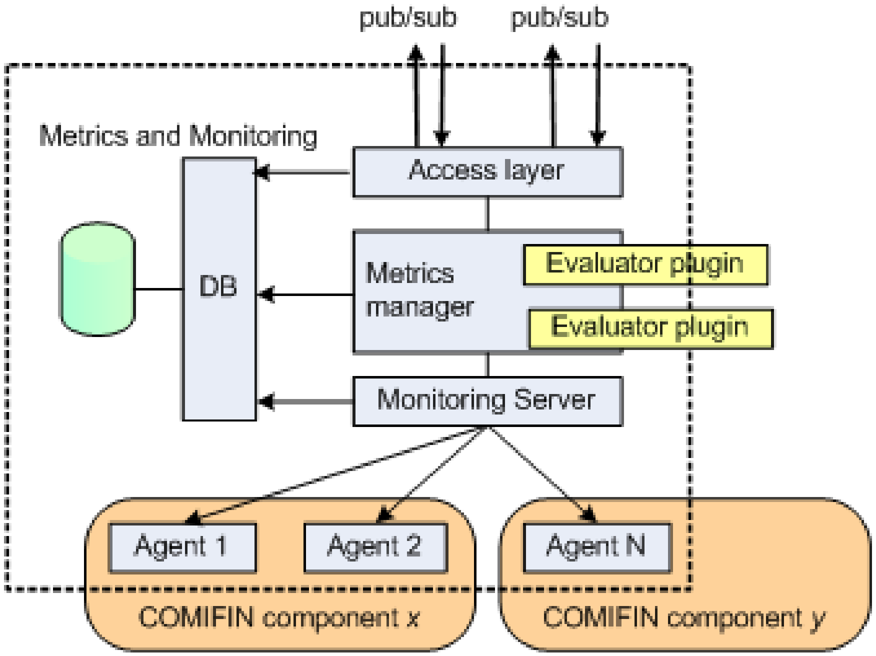


SR_ID	SR_CONTRACT	SR_SCHEMA	SLA
sr_x	<contract/sr_x>	<schema/sr_x>	<sla/sr_x>
sr_y	<contract/sr_y>	<schema/sr_y>	<sla/sr_y>
sr_z	<contract/sr_z>	<schema/sr_z>	<sla/sr_z>
...	...	...	...
...	...	...	...
...	...	...	...

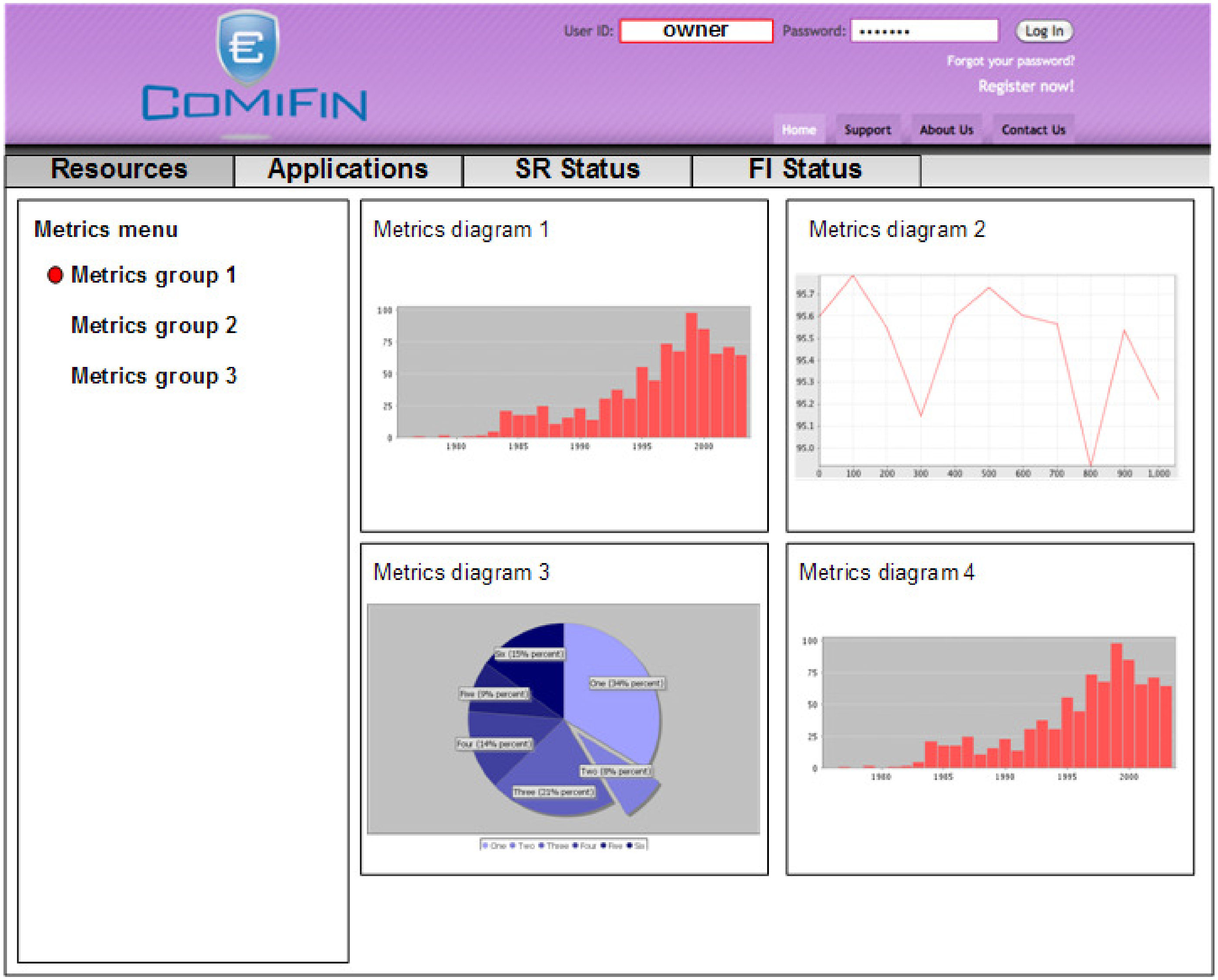
Status: MeMo (SLA Mgr, Evaluator Plug In Rules Engine)


Interfaces provided by SLA Manager permitting MeMo to notify SLA violations/warnings

Interfaces provided by MeMo permitting SLA Manager to notify the creation, modification or deletion of SLAs.



Dashboard Manager



User ID: owner

Password: •••••••

Conclusions and Future Work

- ❑ Status
  - Metric based definition of SLAs (Generalized IoT Model)
  - Semi-automatic generation of monitoring configuration from metrics and SLA definitions
  - Multi-level metric evaluation system to handle complexity
  - MeMo driven SLA Adaptation

- ❑ Future work
  - Formal models of security measurement and Metrics
  - Privacy metrics

- ❑ www.comifin.eu: Communication Middleware For Monitoring Financial Critical Infrastructures