Security for smart Electricity GRIDs

Intrusion Tolerant SCADA

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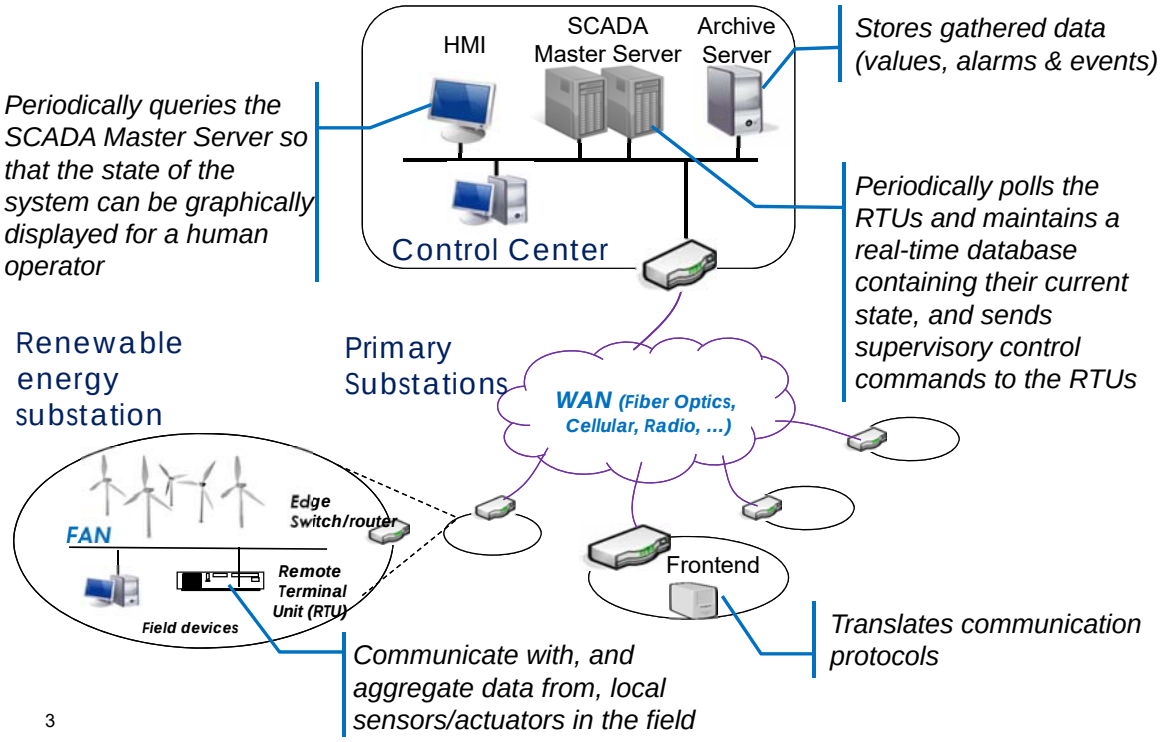
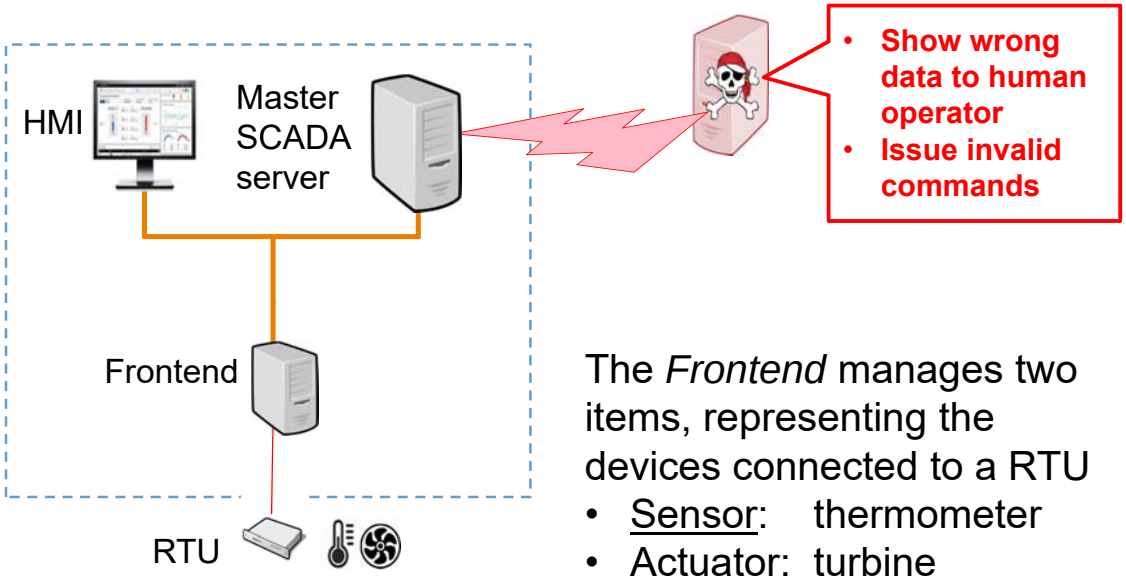
Goal: Demonstrate a SCADA system capable of tolerating intrusions

- Show how an attacker can corrupt the execution of a critical infrastructure by compromising the SCADA Master server
- Show a more resilient SCADA solution, where the SCADA Master maintains system correctness in the presence of intrusions

Simplified SCADA system



Demo scenario



The *Frontend* manages two items, representing the devices connected to a RTU

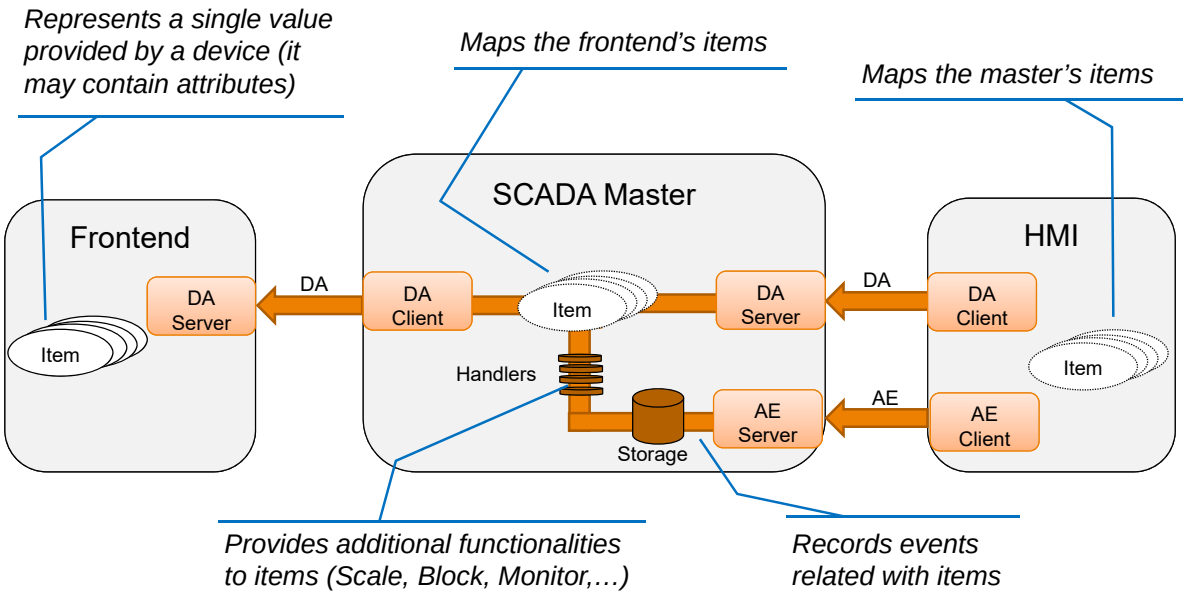
- Sensor: thermometer
- Actuator: turbine

The prototype and experimental environment

Prototype

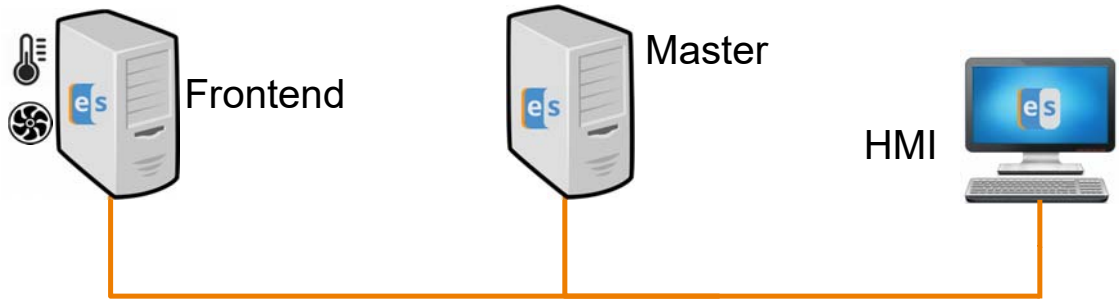
- System based on the **Eclipse SCADA** open source project
- Eclipse SCADA provides a modular “construction kit” to create a custom SCADA
- IBH SYSTEMS GmbH is the leading contributor
- In production for instance at:
  - E.ON solar plants
  - OMV business processes

EclipseSCADA: Components



Experimental Environment

- Eclipse SCADA & Emulated RTU Items



Demonstration

Demonstration: 4 Steps

1. Interact with RTU items using Eclipse SCADA
2. Impact of an intrusion in the SCADA Master
3. Interact with RTU items using intrusion-tolerant Eclipse SCADA
4. Impact of an intrusion in a SCADA Master replica

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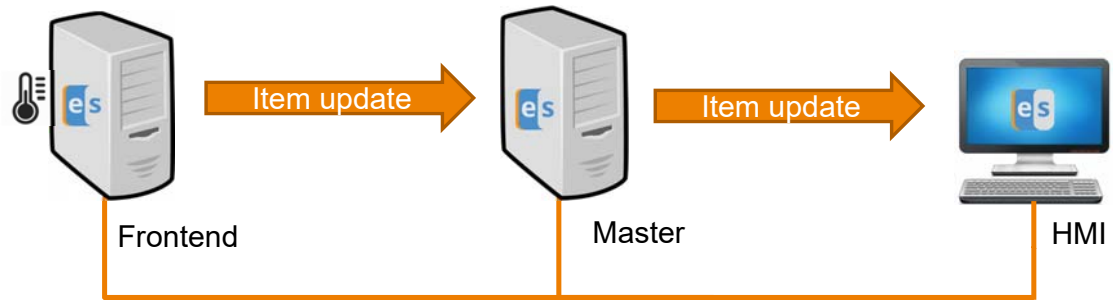
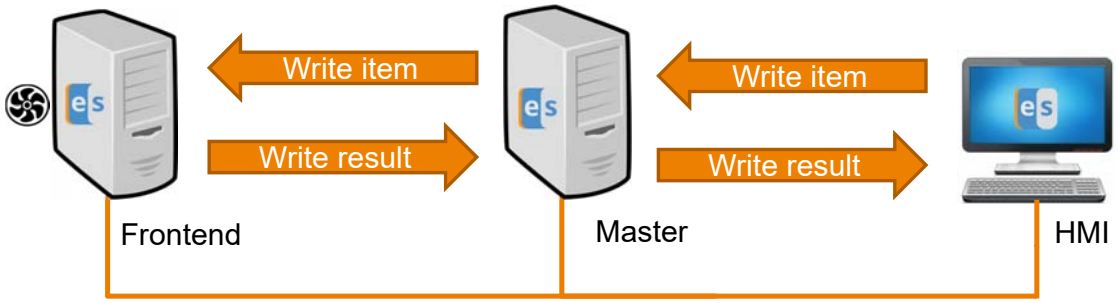
Use cases

- Simulate temperature updates in thermometer item 
- Simulate switch on/off commands in turbine item 
- Setup an alarm that goes off if the temperature reaches a threshold value

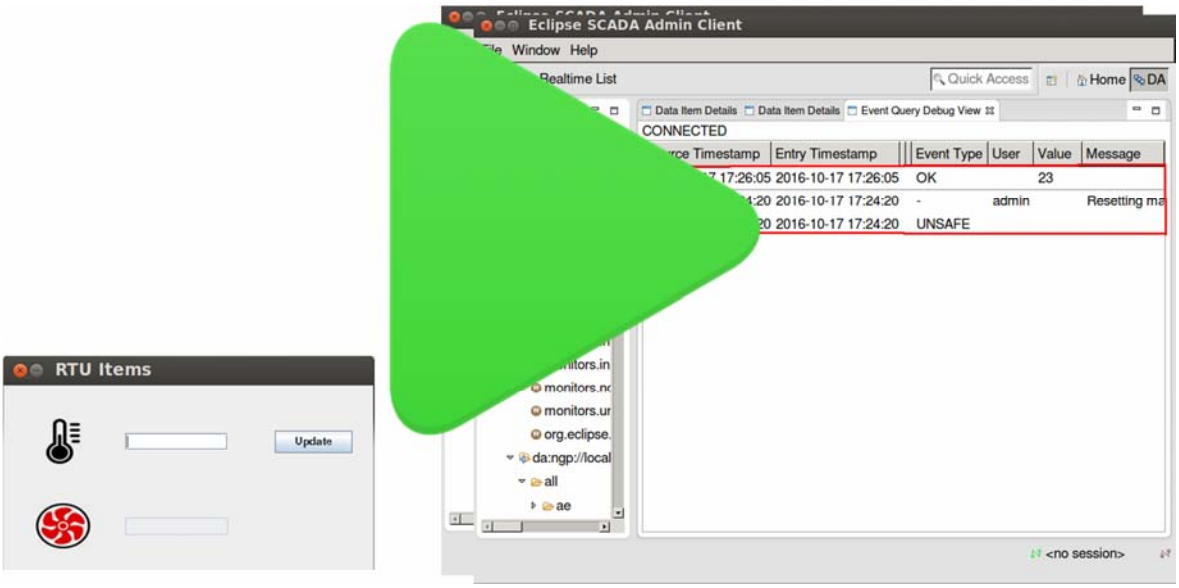
Thermometer Item use case



Turbine Item use case



Demo



Frontend **HMI**

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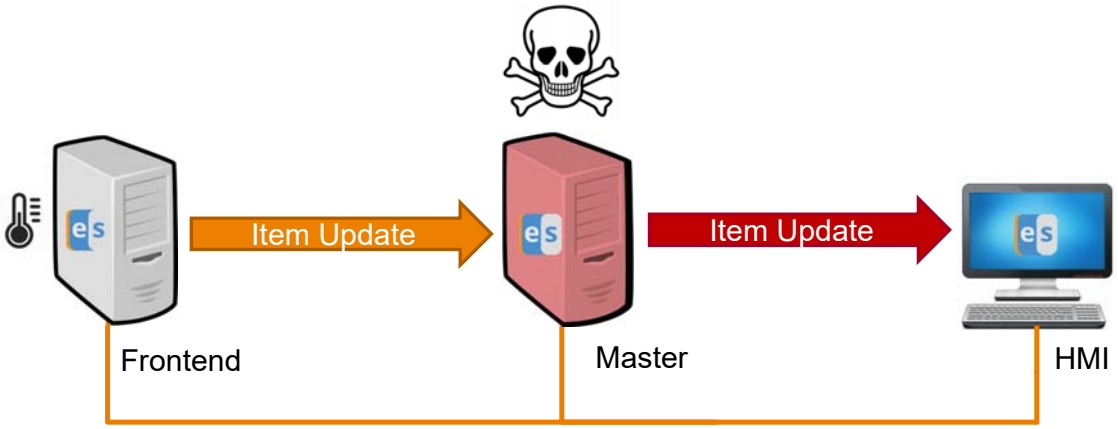
Attack scenario

- An attacker gains access to the Master
- Modify data exchanged between the Frontend and the HMI

Thermometer Item use case



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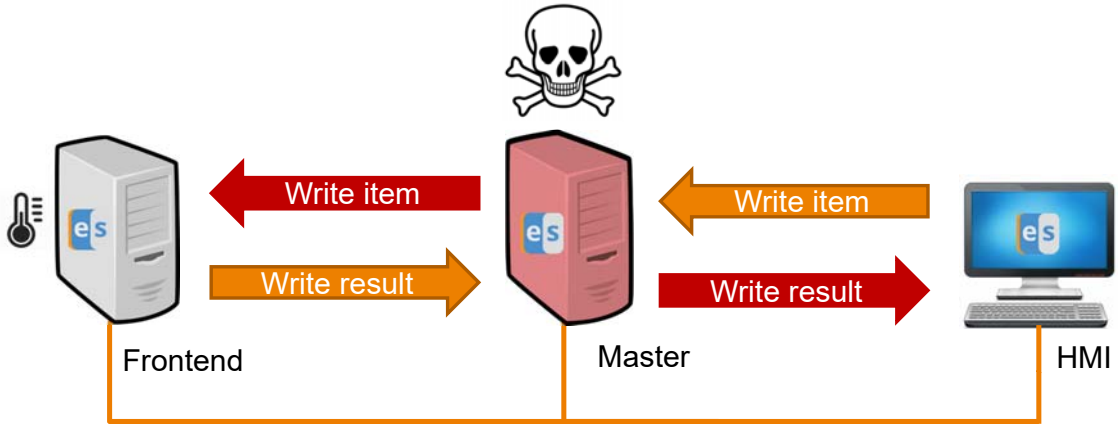
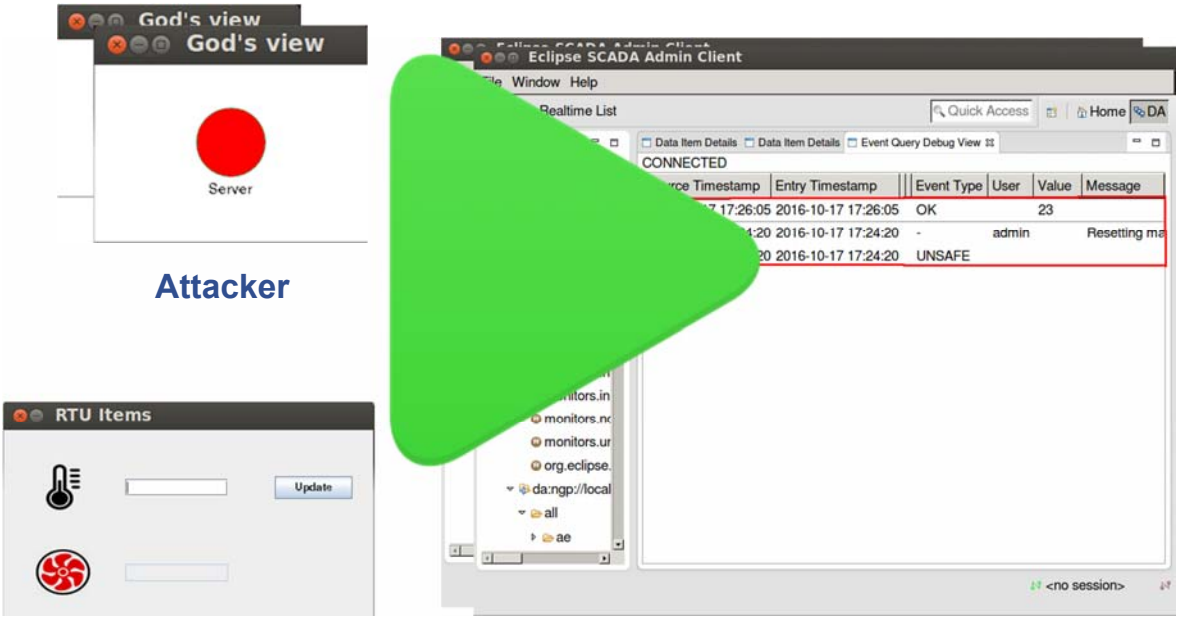


Demo



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Prototype

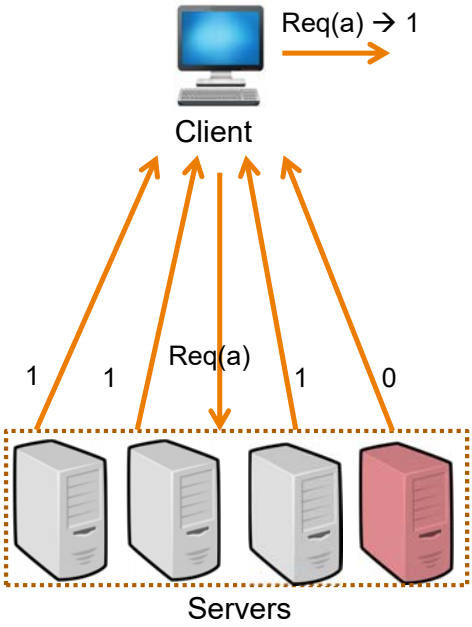
- Intrusion-tolerant Eclipse SCADA
  - Modified Eclipse SCADA to support the **replication** of the SCADA Master
  - Integrated a **Byzantine fault-tolerant state machine replication library** developed in Java, called BFT-SCADA
  - Explores results from other European projects involved in the development of the BFT-SMART library: Massif, Tclouds, Supercloud

How does BFT-SMART work?

1. Every client request is processed by a group of servers
2. Servers must execute the same sequence of requests
3. The client infer the correct result of a request from the majority of the answers

- Servers coordinate to decide the order of request processing
- Servers should run diverse softw/hardw
- Weakest possible failure assumption

  n= 3f+1 (f=1, n=4)

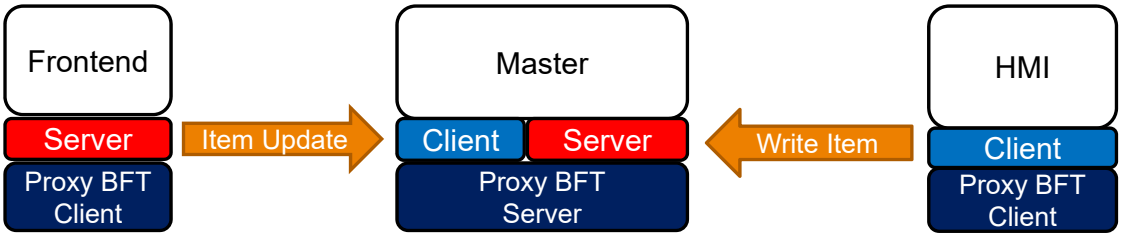


Eclipse SCADA integration challenges

- Eclipse SCADA is a framework and not a ready-to-use solution
- Reasonably large project size
  - more than 500 sub-projects → 6100 Java files (900.000 LOC)
- Poor software documentation
  - source code
  - use cases examples

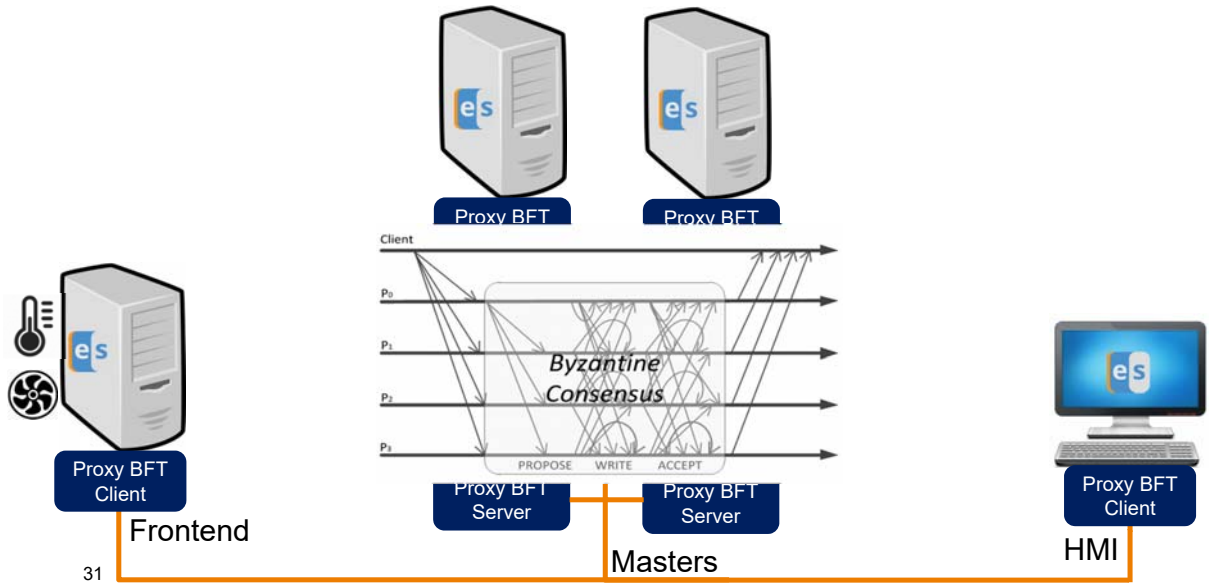
Eclipse SCADA integration challenges (cont)

- Multiple I/O channels

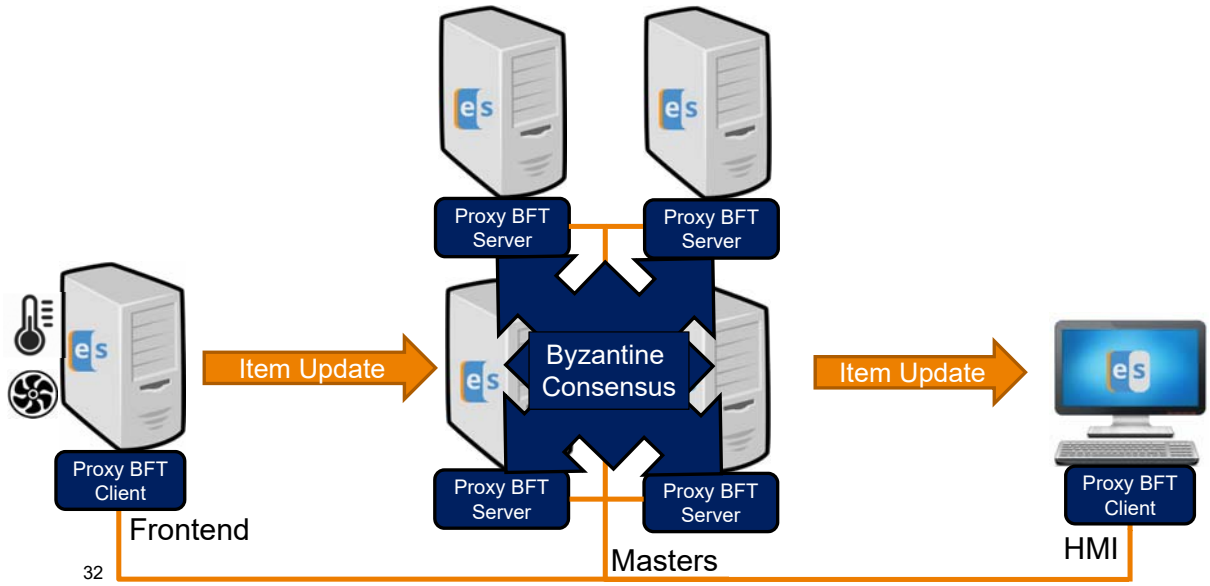


- Concurrency through multiple threads
- Asynchronous messages
- Non-deterministic actions (e.g., get timestamps)
- Performance

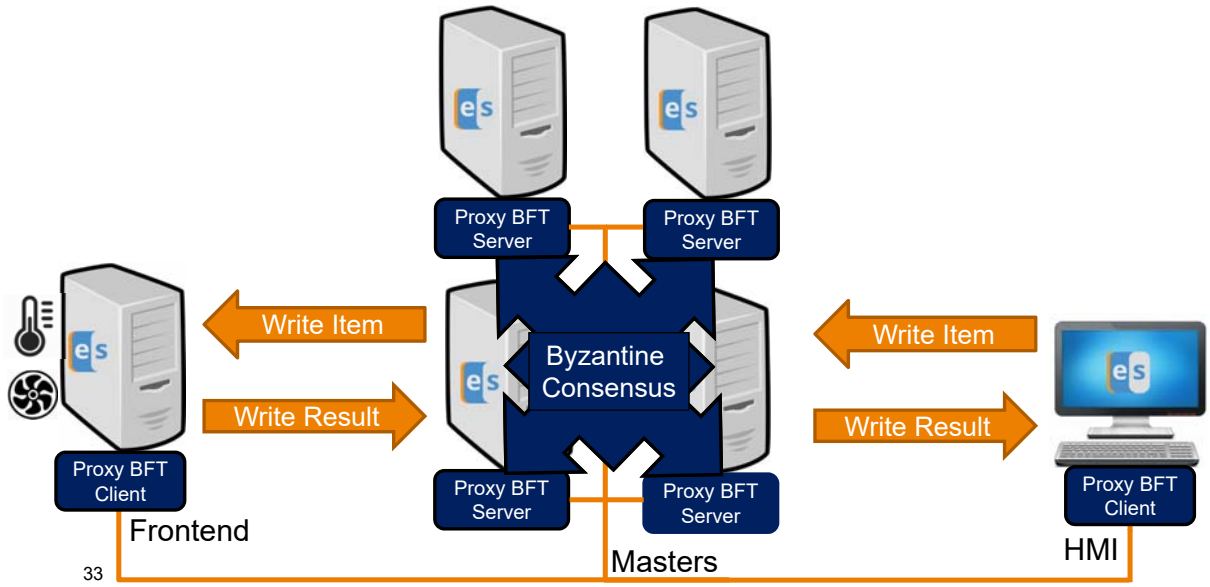
Intrusion tolerant operation



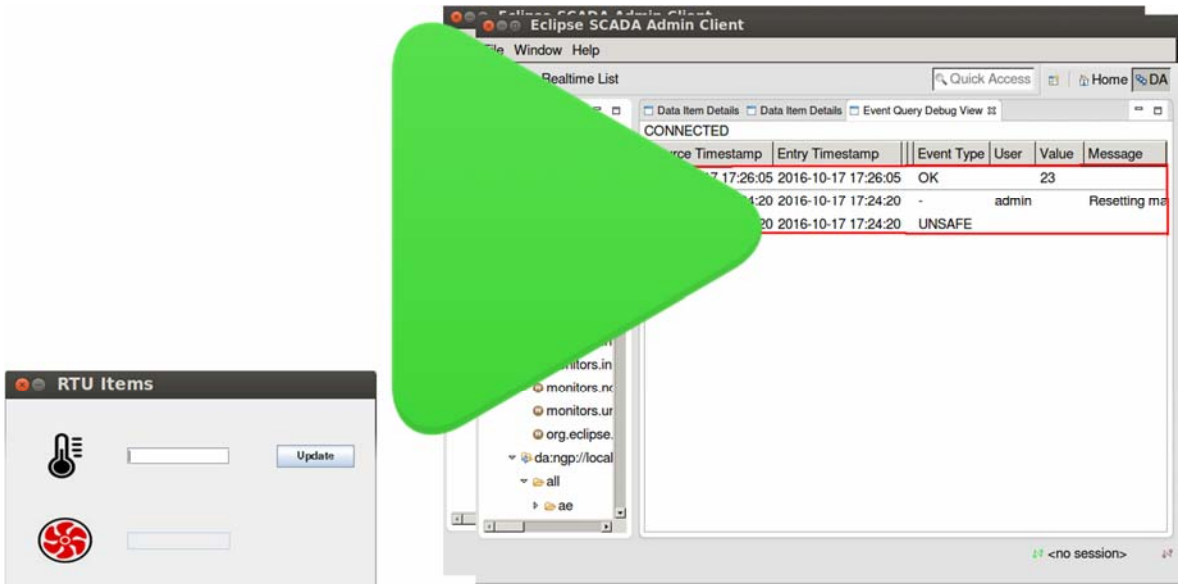
Thermometer Item use case



Turbine Item use case



Demo



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- Modifies data exchanged between the Frontend and the HMI

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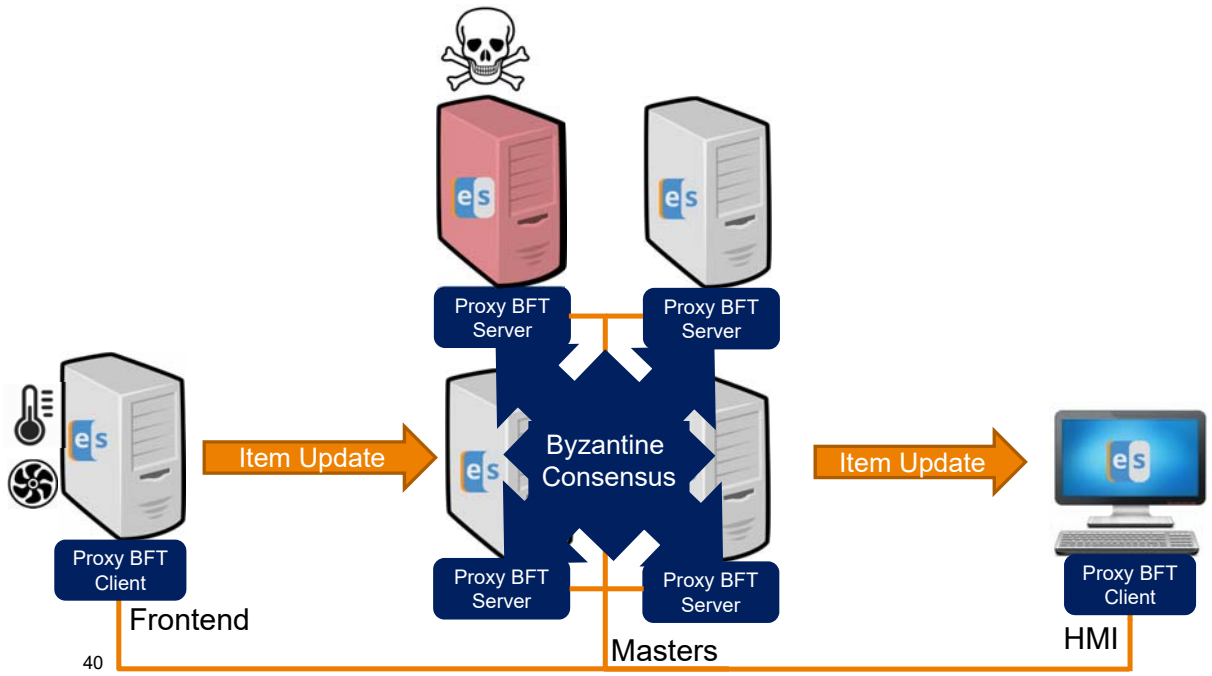

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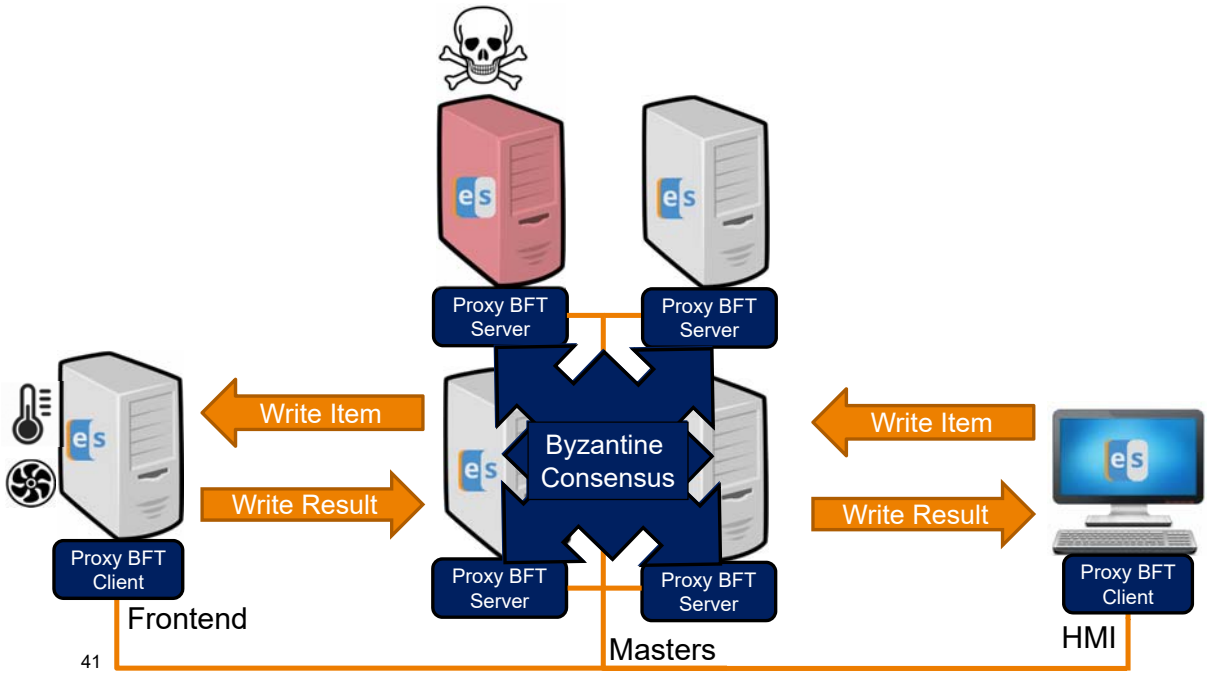
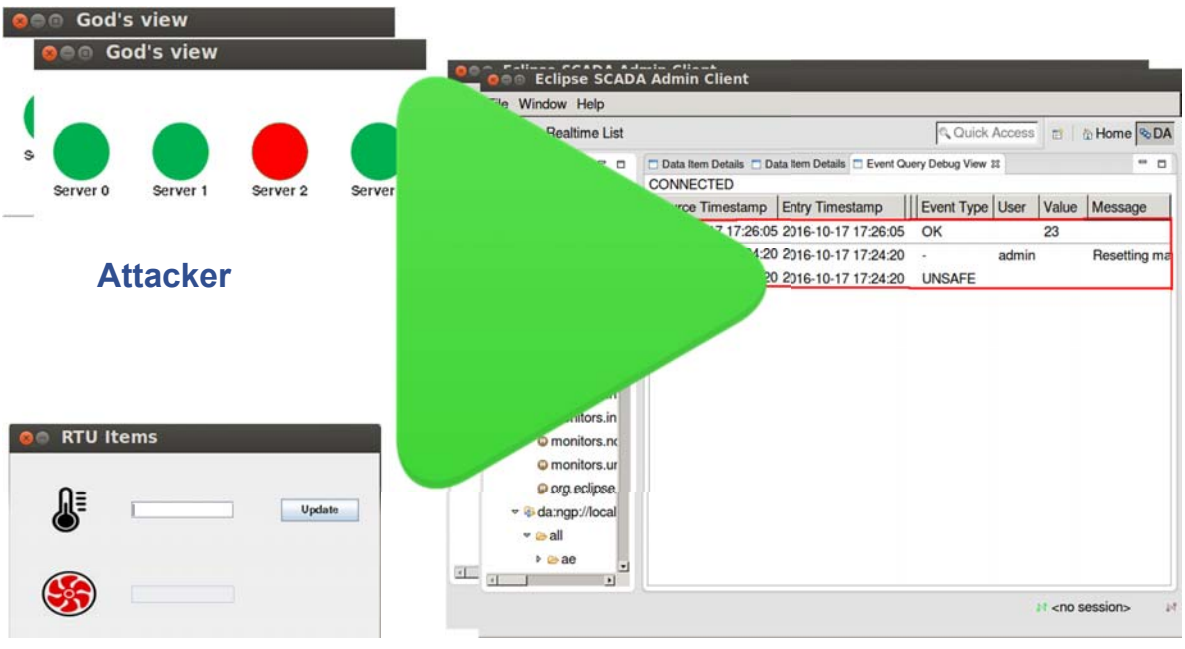
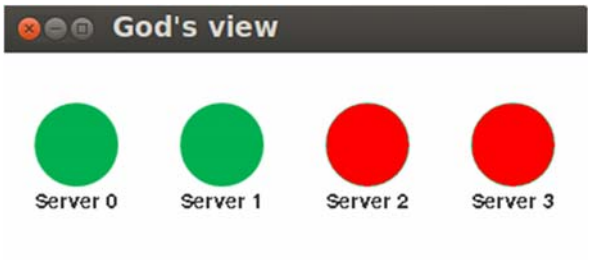


Demo



Byzantine fault-tolerant limitations

- What happens when more than *f* replicas are compromised?



  - If 2 replicas are compromised, the system stops making progress, but does not do mistakes
  - If 3 replicas are compromised, then a clever attacker can make the system take incorrect actions

Thank you! Any questions?

This was:

Intrusion-Tolerant SCADA

Web: http://segrid.eu

http://www.navigators.di.fc.ul.pt