Intrusion Tolerant SCADA

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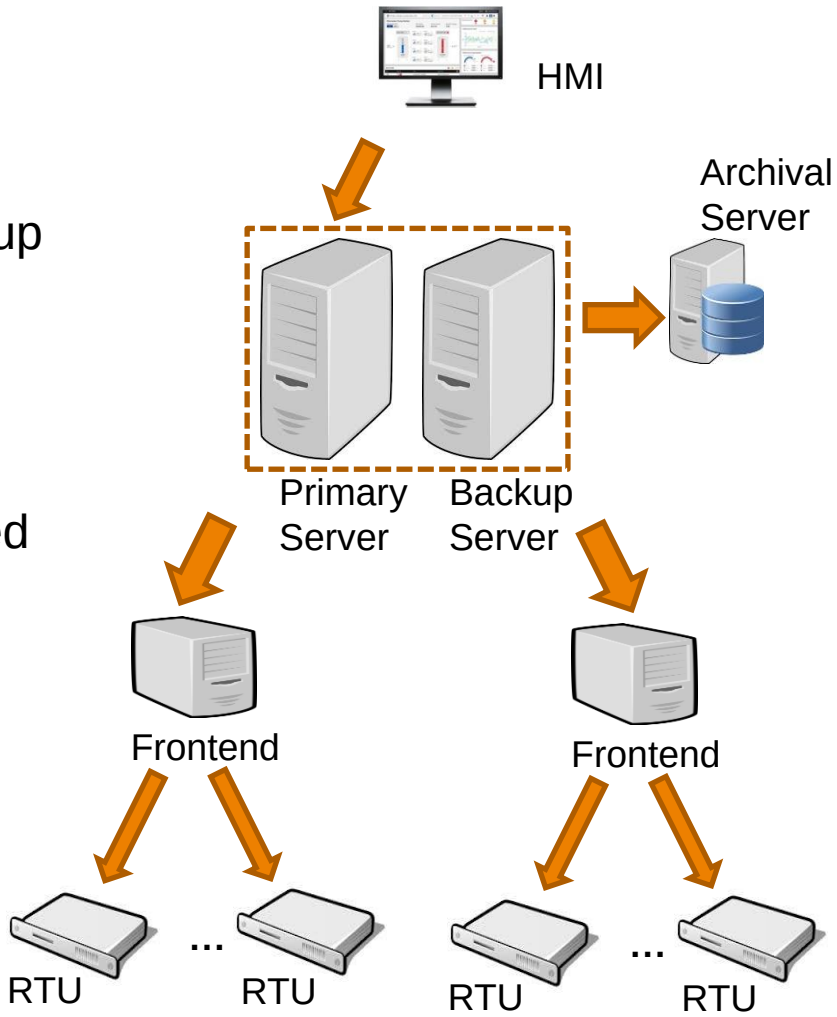
SCADA: Example Industrial Facilities

Master SCADA Server Tolerant to Crashes

- Redundancy method with two identical replicas to tolerate crashes
- Upon failure of the primary server, the backup replica takes over, replacing it
- The backup replica can operate as a hot/warm/cold standby
- The backup replica needs to be kept updated

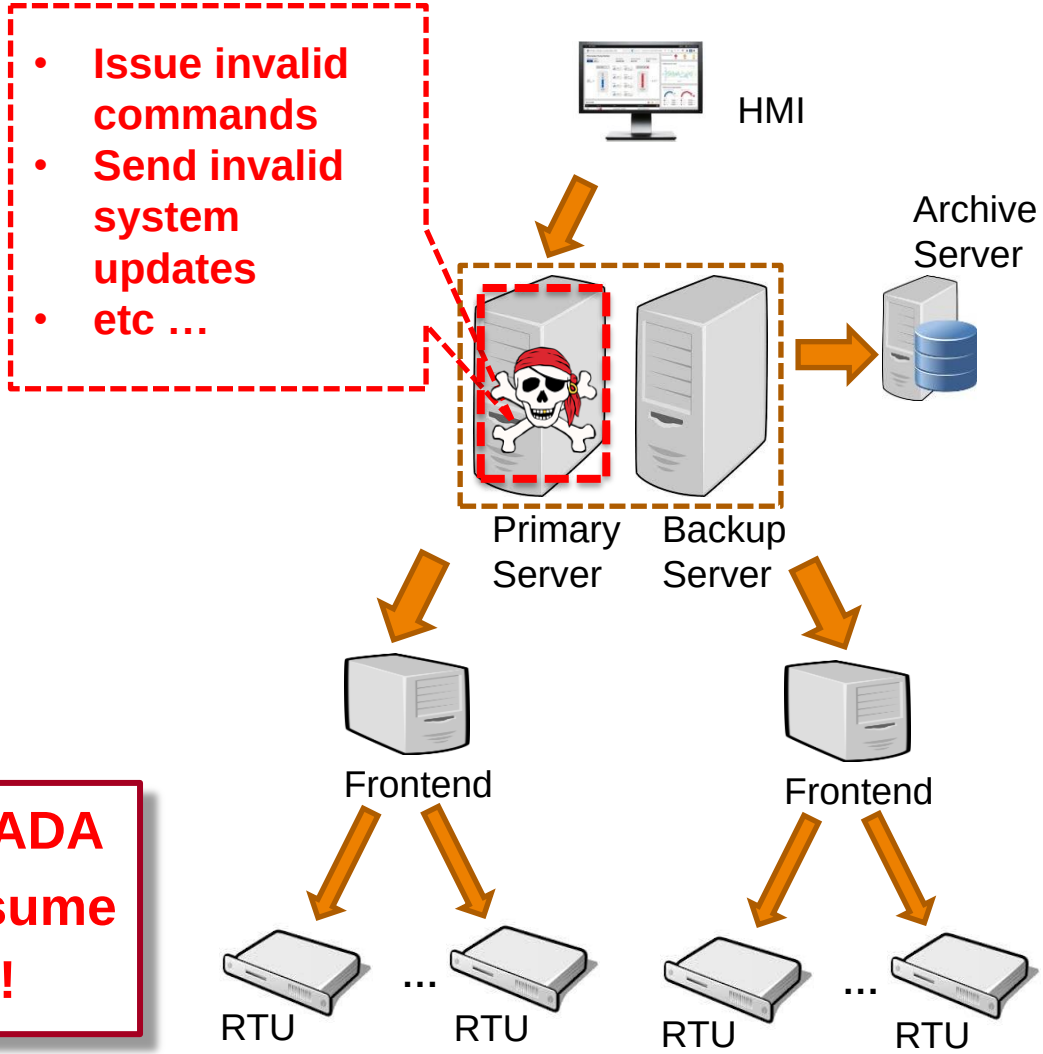
- Tolerates one crash fault
- Relatively short downtime period



Scenarios of SCADA under Attack

- Reported advanced cyber attacks continues to rise
  - ➢this is particularly visible in the electrical area with many described incidents
- Add intrusion prevention using standard IT security technologies
  - ➢Firewalls
  - ➢IDS

Given the criticality of the SCADA system it is prudent to assume that prevention is not perfect !



How to make a system intrusion tolerant?

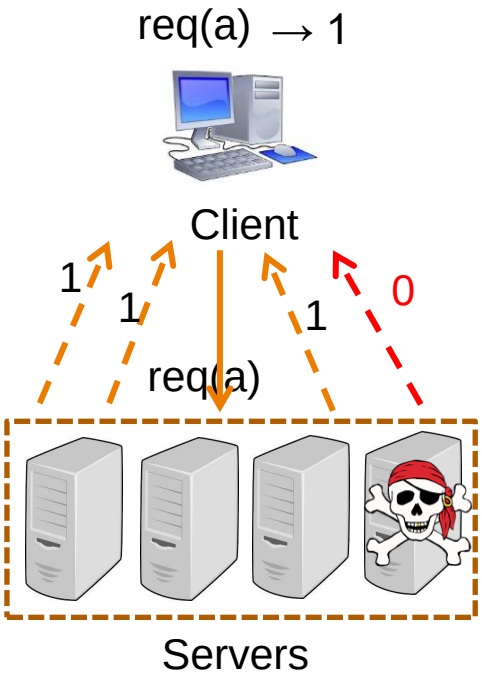
Main ingredients:

- High level of mistrust in all components
- Assume a bound on the number of replicas compromises

Use State Machine Replication (or Active Replication) to tolerate arbitrary/Byzantine faulty behavior

- Weakest possible failure assumption

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



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

- Servers coordinate to order the request processing
- Servers should run diverse software

Putting the Idea into Practice!

- Develop an intrusion tolerant SCADA Master server
- Integrate an active replication library with an open source SCADA
- Achieve a performance level to be used in the field

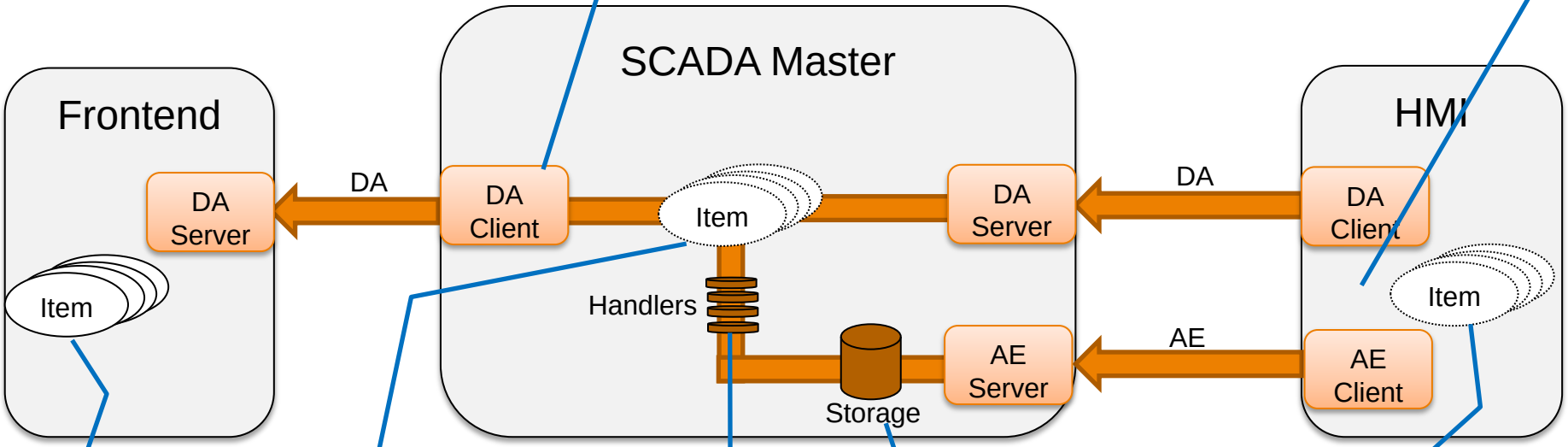
Some of the challenges:

- Find a suitable open source software → **EclipseSCADA**
- Project size (more than 500 sub-projects → **900.000 LOC**)
- Limited documentation
  - source code
  - use case examples
- EclipseSCADA is a framework and not a ready-to-use solution

EclipseSCADA: Overview of Components

Performs Data Acquisition (DA) operations such as SubscribeItem, WriteValue,…

Performs DA operations such as SubscribeEventItem, SubcribeMonitorItem,… Gets Alarms & Events (AE) that were setup



Represents a single value provided by a device(it may contain attributes)

Maps the frontend's items

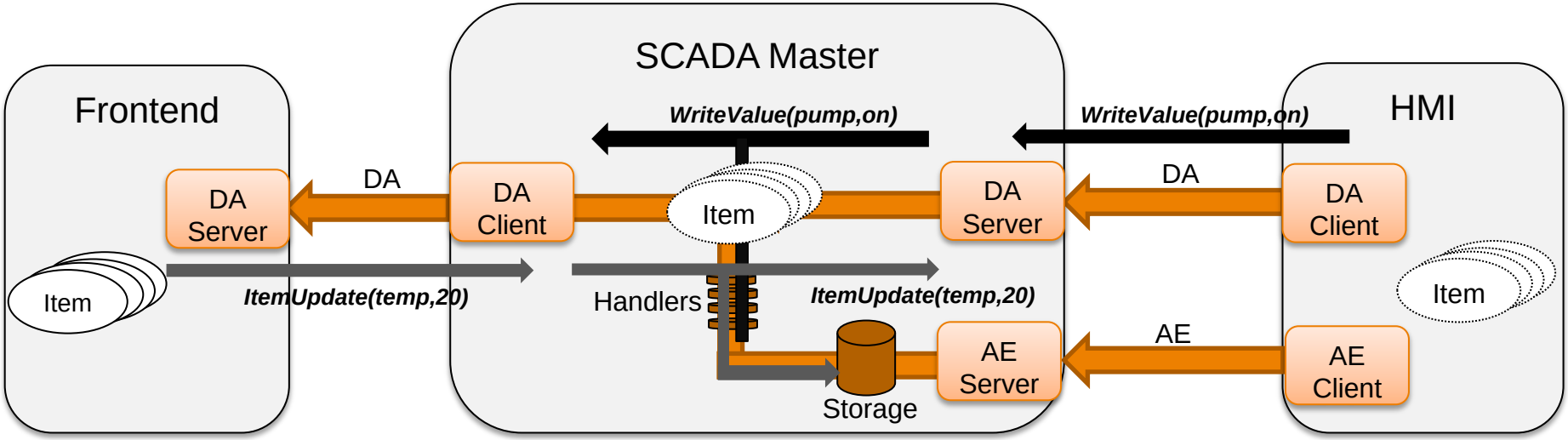
Provides additional functionalities to items(Scale,Block, Monitor,…)

Records events related with items

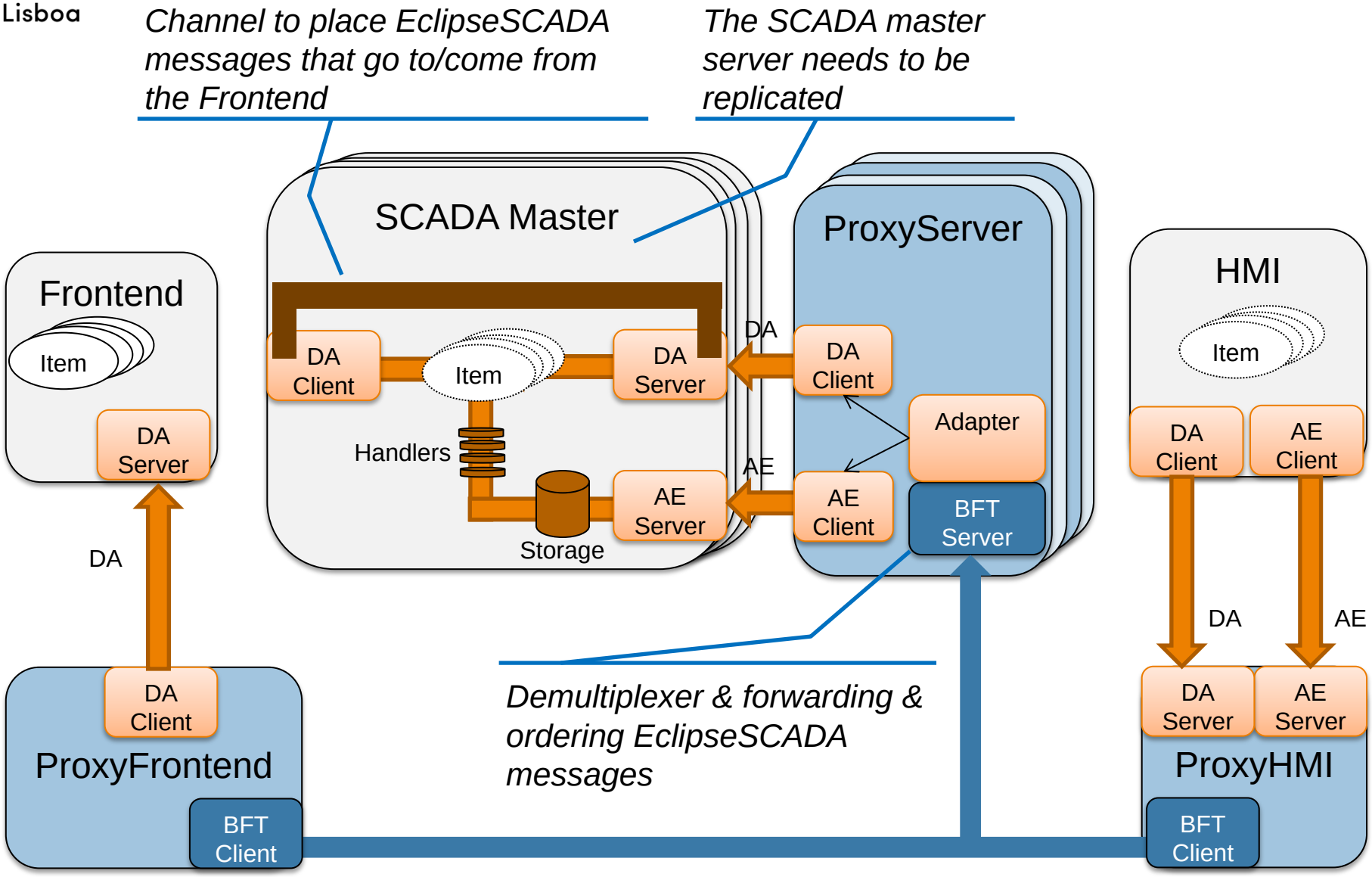
Maps the master's items

Challenges for replication

- Multiple I/0 channels
- Concurrency of processing
- Timestamps
- Asynchrony of message arrival
- Performance
- *Minimize changes in the code*



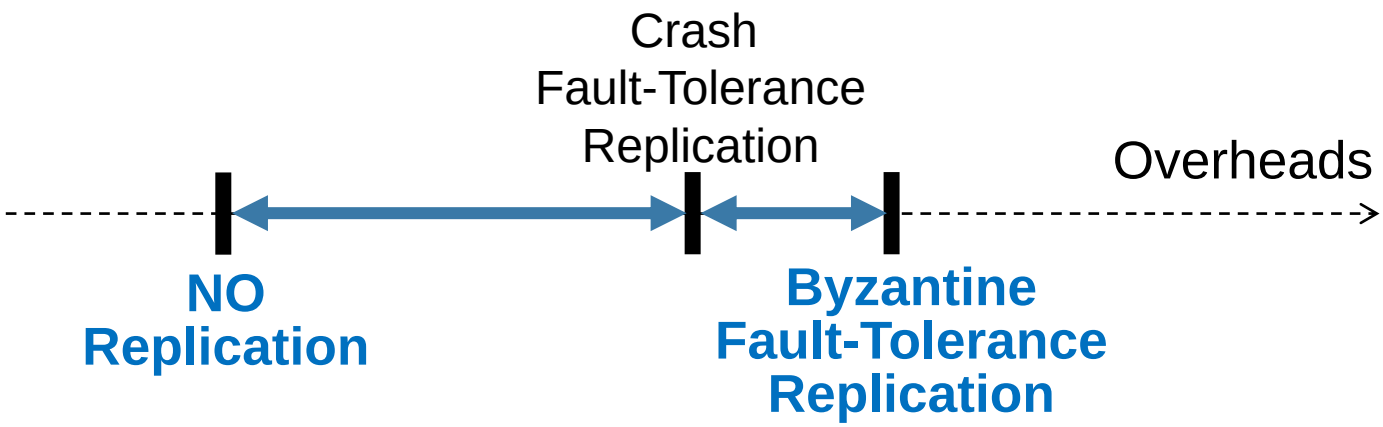
Resilient EclipseSCADA



Preliminary Evaluation

- Measure the **impact in performance** introduced by active replication
  - compare the performance of the **EclipseSCADA** and the **BFT EclipseSCADA**

- Hardware setup infrastructure
  - 1 Frontend
  - 4 EclipseSCADA Master Servers
  - 1 HMI

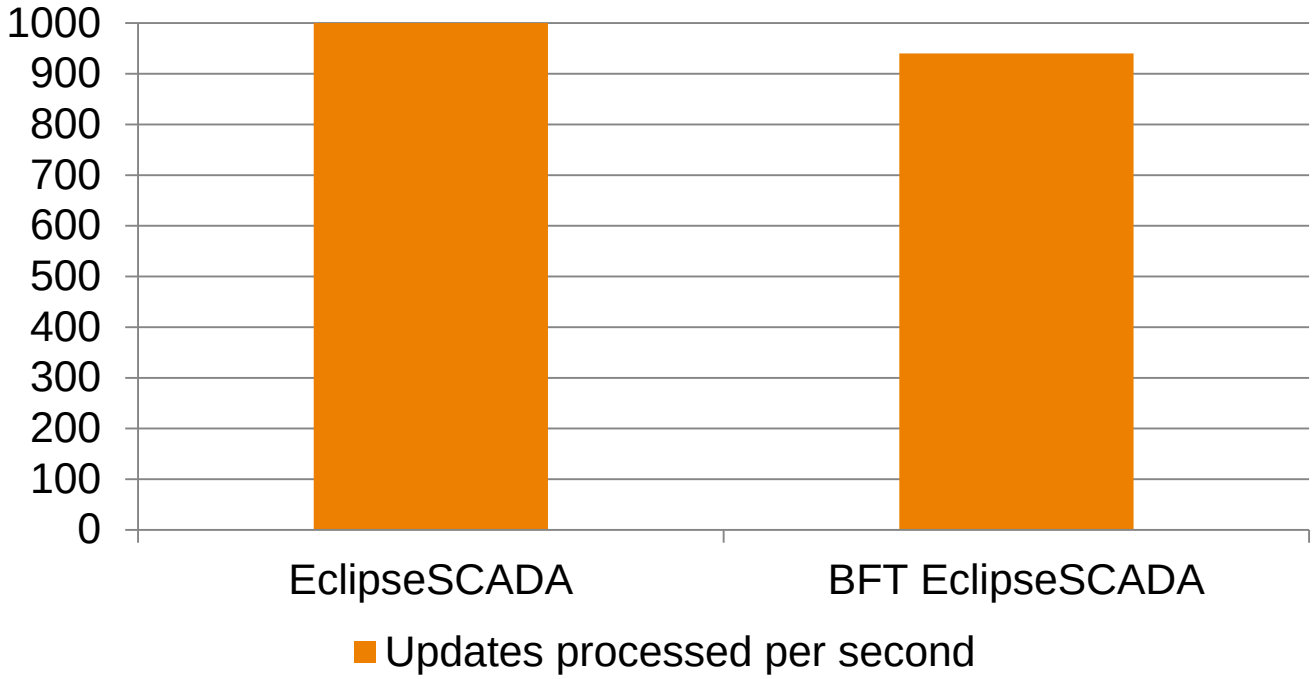


Item update test

Benchmark:

Update 10 items in the frontend

Each item updates itself 100 times per sec



Overhead of 6% mainly explained due

- 2 commun. steps in EclipseSCADA, 6 steps in BFT EclipseSCADA

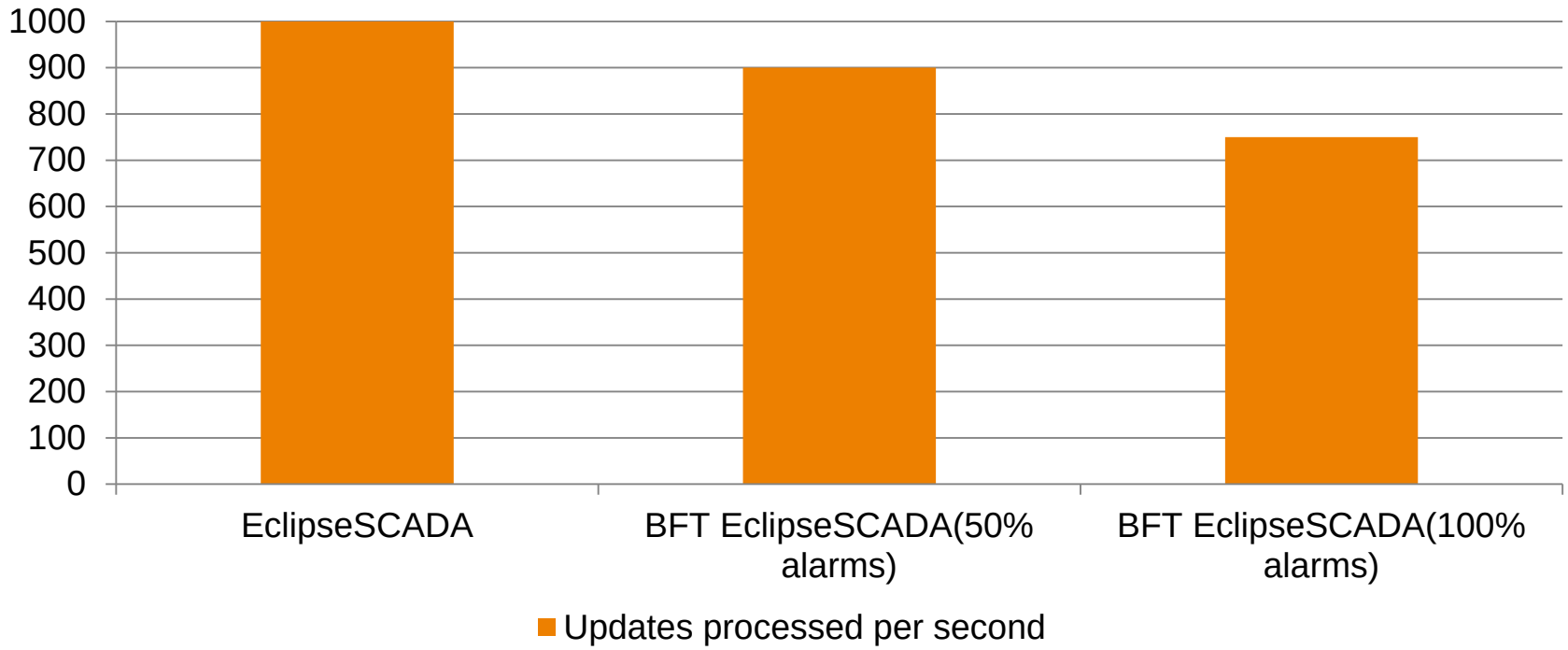
Item updates with alarms test

Benchmark

Update 10 items in the frontend

Each item updates itself 100 times per sec

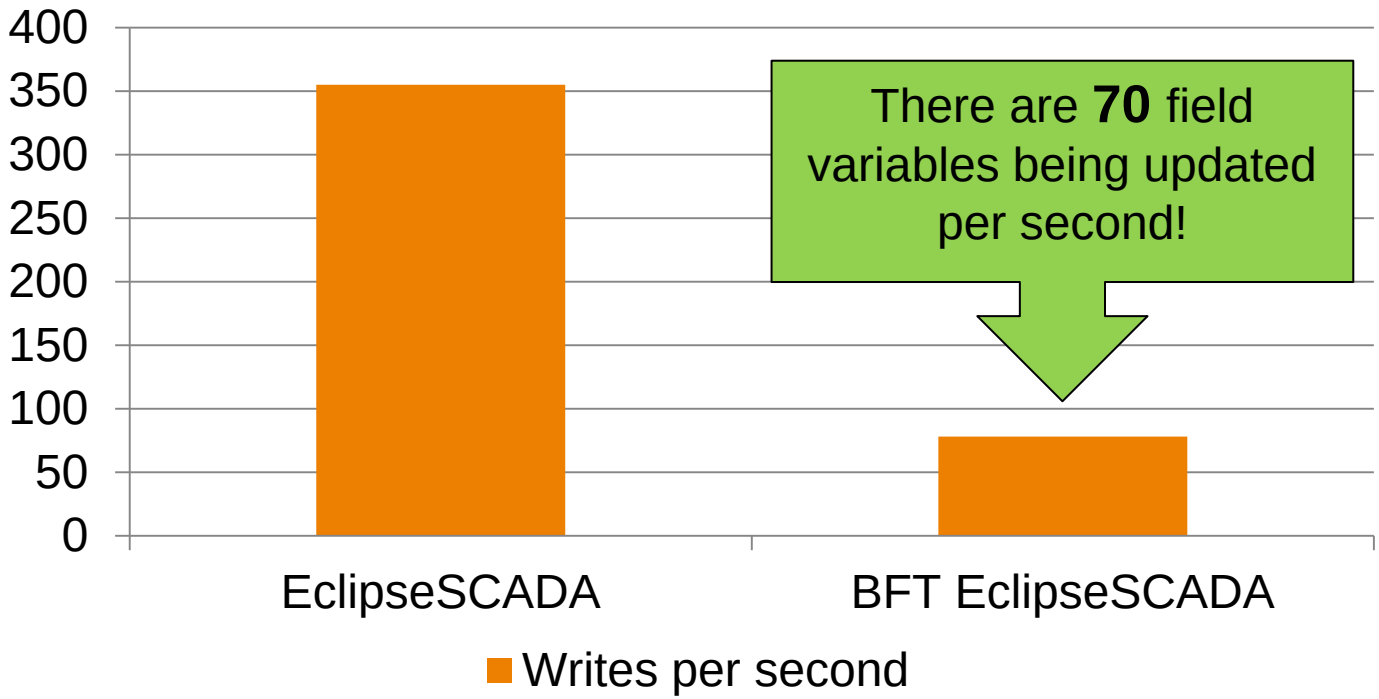
Add monitor handlers



- Overhead of 25% in worst case scenario (with 100% alarms)

Item writing test

Benchmark:
Write synchronously 1 item in the frontend



Overhead of 78%

- **4 steps** in EclipseSCADA, **12 steps** in BFT EclipseSCADA
- The **active replication library** introduces an overhead of **only 12%**

Ciências ULisboa

SEGRID

Thank you! Any questions?

This was:

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