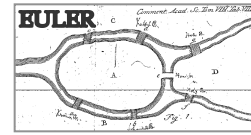


# FIRE Thematic workshop: Measurements and Measurement Tools

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collocated with Future Internet conference  
Aalborg, Denmark  
May 9, 2012



## 09.30 Introduction and motivation of the workshop

Speaker: Dimitri Papadimitriou

- What do we mean by measurement in experimental research context
- In which conditions experimental-research measurements are being performed (what are their actual objectives)
- Up to which extend a measurement tool can be designed if the measurement model is not completely known, etc.

1. Key elements in operation and management of "future networks" at both equipment and shared infrastructure level for
  - Performance evaluation, monitoring, etc.
  - Higher-level control functionality such as on-line data analysis and diagnostic
  
2. Fundamental role in **measurement-based experimental research**: experimental "validation", evaluation and benchmarking of project artefacts (experimental corpus) by means of reliable and verifiable tools, including
  - Functions/modules, agents, etc.
  - Protocols (procedures and messages/format)
  - System/programmable components
  - etc.

## Presenting and discuss

- Current developments on measurement in experimental research projects within FIRE (Future Internet Research and Experimentation)
- Current needs and developments of associated measurement tools in the areas of wireless/sensor networks, information-centric networking, programmable networks, etc.

## Expected outcomes

- i) Identify what can be performed/reached by means of cooperation between research projects from a directory of tools accessible to the FIRE community at large up to the joint development of tools
- ii) Determine commonality in needs and new domains
- iii) Document lessons learned and best practices in tools development for measurement-based experimental research

## Thematic workshop structure

- 11 talks from 9 different FIRE European projects
- organized in four sessions

## Thematic workshop sessions (as initially planned)

- Introduction (motivation, scope, objectives, etc.)
- Session 1: Metrics, measurement and associated tools needs in FIRE
- Session 2: Metrics, measurement and associated tools developed in FIRE
- Session 3: Metrics, measurement and associated tools needs and development outside FIRE
- Session 4: Round table discussion (how to bridge the gap)

Each talk: 20-25 min + 10-5 min discussion

Session chair: Davide Careglio (Universitat Politècnica de Catalunya, Spain), EULER project

- Experimental performance evaluation of sensor-based networking for energy efficiency in smart buildings  
Sotiris Nikolettseas (Research Academic Computer Technology Institute - RACTI, Greece), HOBNET project
- Metrics and measurement tools for assessing the channel condition in a wireless experimentation environment  
Ingrid Moerman (Interdisciplinary Institute for Broadband Technology - IBBT, Belgium), CREW project
- Methods and tools for temporal Web analytics  
Marc Spaniol (Max-Planck-Institut für Informatik - MPI-INF, Germany), LAWA project
- Metrics and measurement tools needs in Information-Centric Networking and CONVERGENCE in particular  
Nicola Blefari Melazzi (University of Rome "Tor Vergata", Italy), CONVERGENCE project

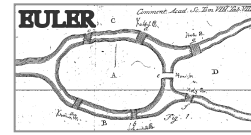
## Session chair: Josep Lluís Marzo (Universitat de Girona, Spain), EULER project

- Metrics and measurement tools needs in OpenFlow and OFELIA in particular  
Hagen Woesner (European Center for Inf. & Communication Technologies - EICT, Germany), OFELIA project
- Delivers control and experimental plane middleware to facilitate early use of its large scale shared experimental facility by researchers  
Anastasius Gavras (Eurescom, Germany), OpenLab project
- Metrics and measurement tools for distributed and adaptive routing algorithms  
Dimitri Papadimitriou (Alcatel-Lucent Bell Labs, Belgium), EULER project

Session chair: Davide Careglio (Universitat Politècnica de Catalunya, Spain), EULER project

- Measurements and measurement tools in OpenLab  
Javier Aracil (Universidad Autónoma de Madrid - UAM, España), OpenLab project
- NOVI's experience in monitoring tools and measurements  
József Stéger (Eötvös Loránd University - ELTE, Hungary), NOVI project
- NITOS: Methods and measurement tools for experimentation on wireless testbeds  
Thanasis Korakis (Centre for Research and Technology Hellas - CERTH, Greece), CONECT project



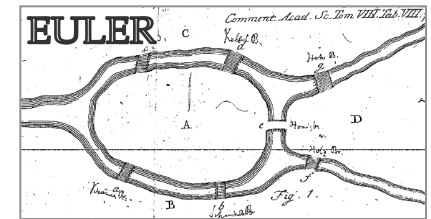


## Thematic workshop website

- FIRE Wiki: <http://bit.ly/HbAxLW>

## Thematic workshop organized by the EULER FP7 research project

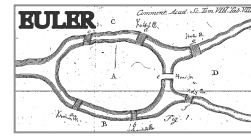
- Website: <http://www.euler-fire-project.eu>
- STREP project (36 months, started on Oct.2010) of the FIRE initiative



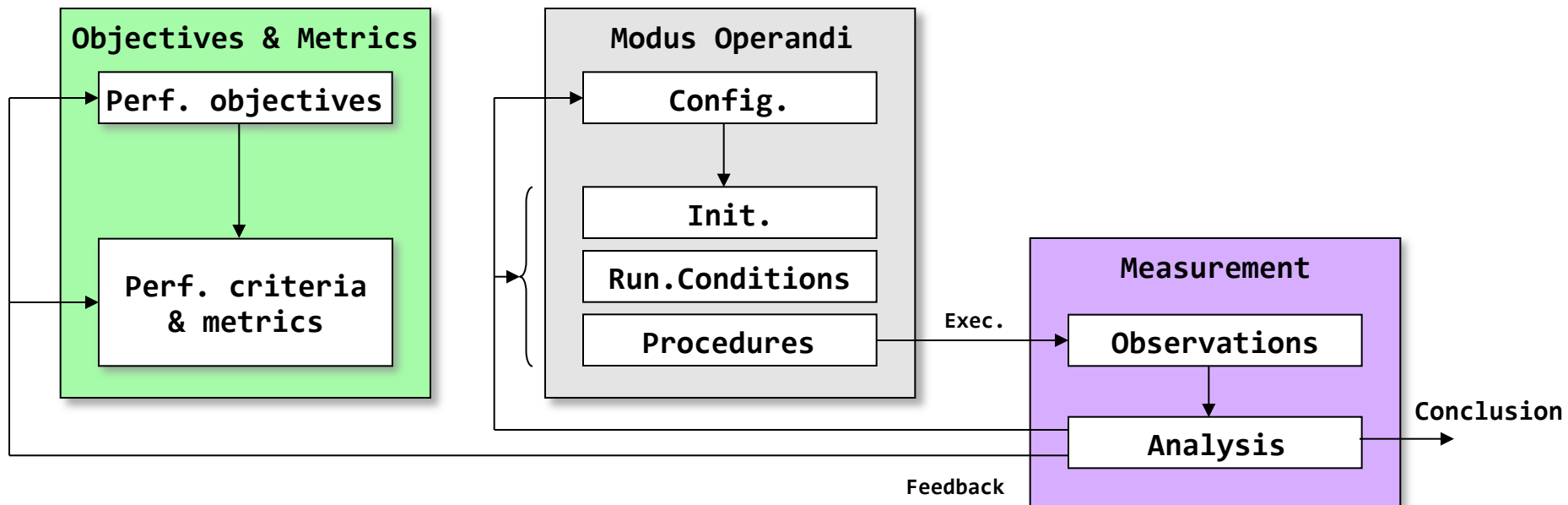
## EULER Mailing list subscription

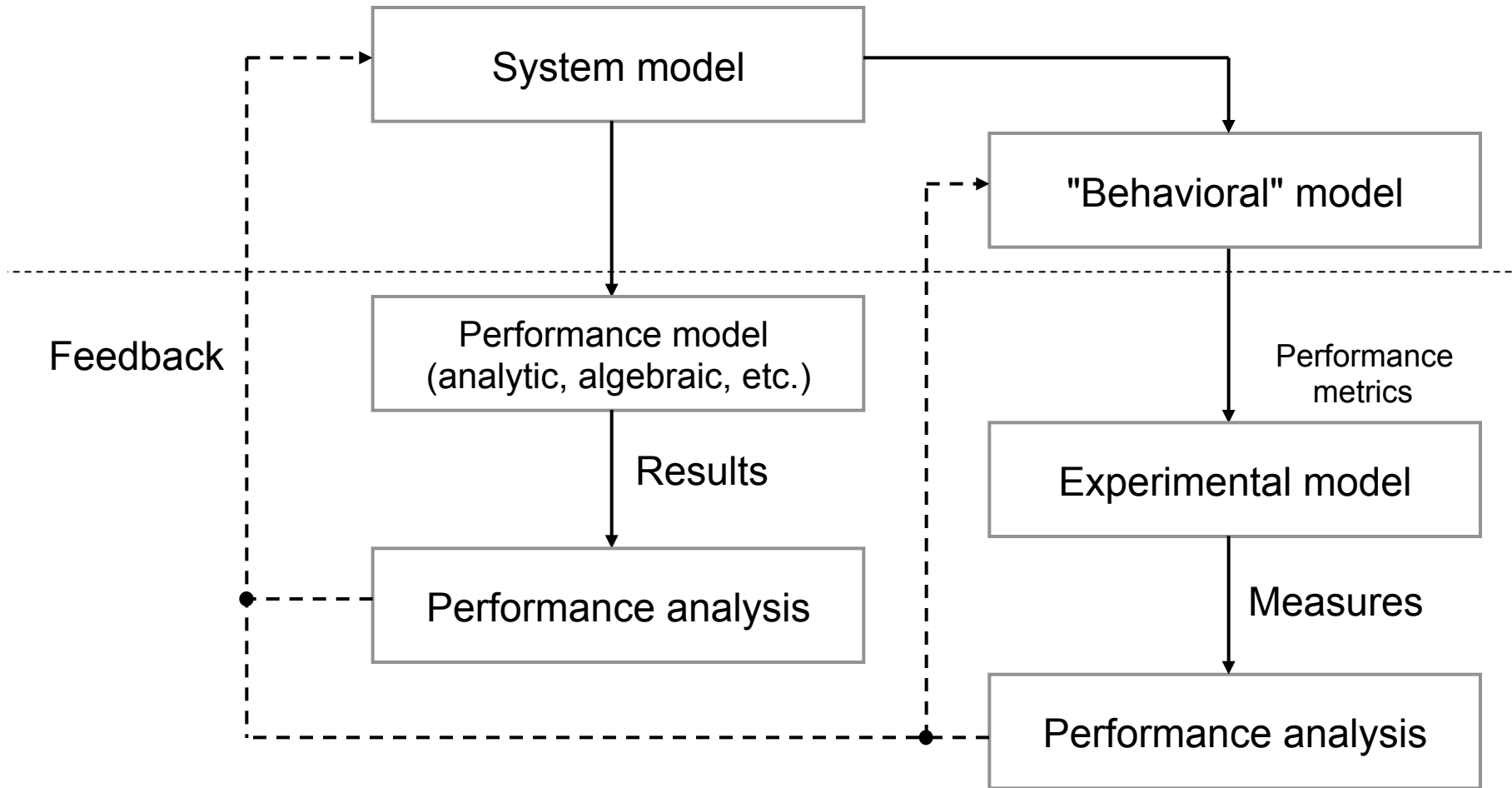
- URL: <https://lists-sop.inria.fr/sympa/subscribe/euler-news>

# Experimental methodology: Performance evaluation and analysis



- Performance
  - Objectives, (technical and non-technical) constraints, and description of expected results
  - Criteria and Metrics
- Modus operandi: configuration, initialization, and running conditions and (iterative) procedure(s) to be executed
- Measurement and reporting including feedback on each iteration



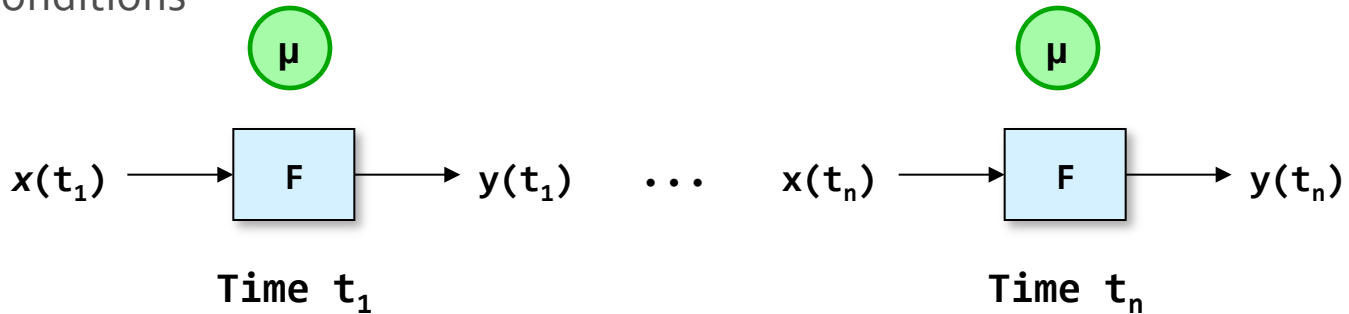


Experimental ICT research -> distributed measures

Challenges associated to (distributed) measurements can be summarized using following dimensions

- Measurement tool properties and calibration
- Measurement timing and synchronization
- Measurement granularity, sampling and representativeness
- Measurement data properties (no meta-info, timestamps)
- Measurement data analysis, reproducibility and referential

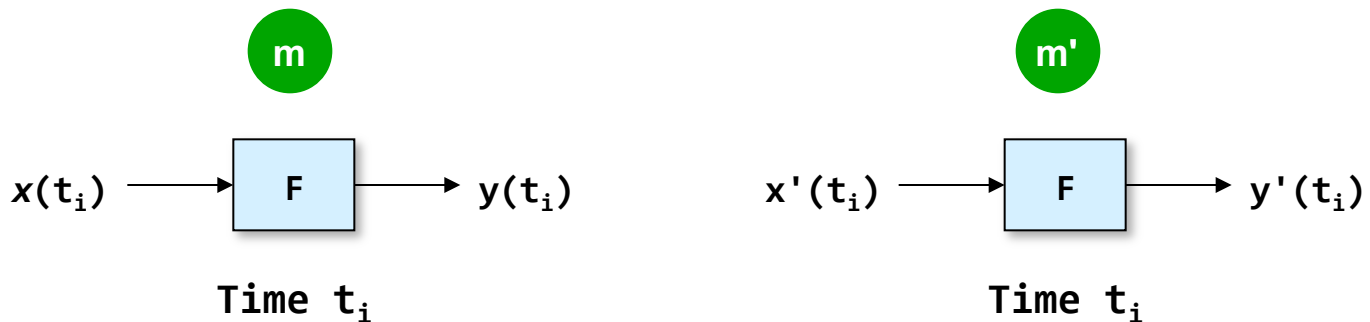
- Reliable:** probability that the **measurement function**  $\mu$  performs its intended measure (output) during a specified period of time under stated conditions



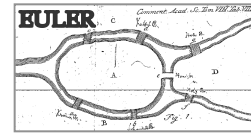
$$\exists [t_1, t_n] \text{ such that } \forall k \in \mathbb{N}, 1 \leq k \leq T$$

$$F(x(t_k)) = \mu(y(t_k)) \mid \mu(y(t_k)) \in [y(t_1), y(t_n)]$$

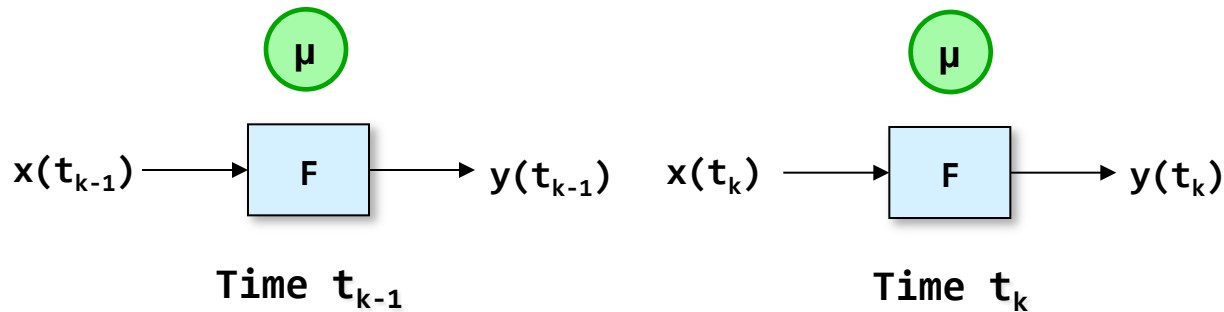
Different implementation  $m$  and  $m'$  of the same measurement function  $\mu$



$$\exists m, m' \in M, \text{ if } x(t_i) = x'(t_i) \text{ (} i = 1, \dots, n \text{) then } m(y(t_i)) = m'(y'(t_i))$$

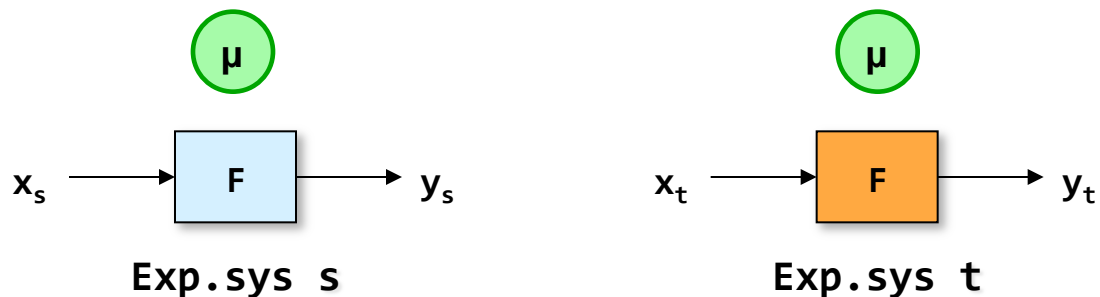


- **Repeatable** (refers to time)



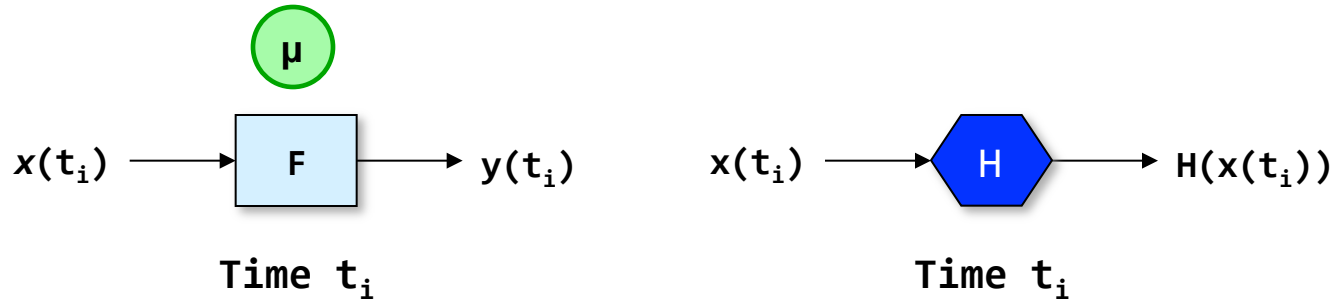
$\forall k \in \mathbb{N}$   
 if  $x(t_k) = x(t_{k-1})$   
 then  $\mu(y(t_k)) = \mu(y(t_{k-1}))$

- **Reproducible** (refers to space)



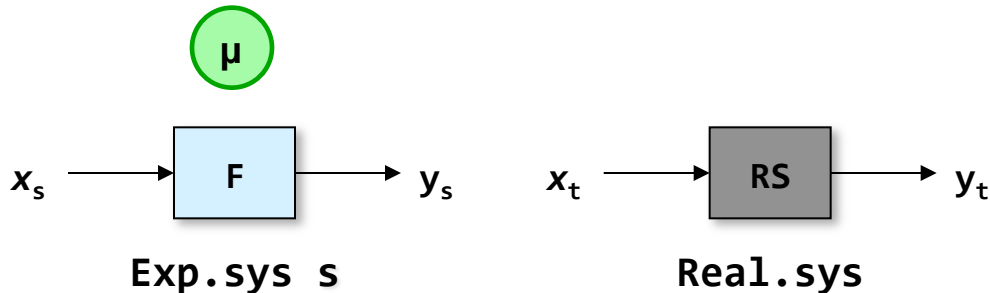
$\exists s, t \in S$   
 if  $x_s = x_t$   
 then  $\mu(y_s) = \mu(y_t)$

- **Verifiable:** wrt model H of function F



$\exists H: \mathfrak{R}^n \rightarrow \mathfrak{R}: x \rightarrow H(x)$  and  $\varepsilon \ll \theta$   
 such that  $H(x(t_i)) \in [\mu(y(t_i)) - \varepsilon; \mu(y(t_i)) + \varepsilon]$

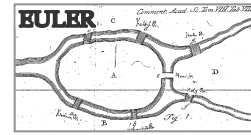
- **Verifiable:** against real system reference (-> **representative** if verified on a representative sample)



$\exists s \in S$  and  $\varepsilon \ll \theta$   
 such that if  $x_s = x_t$   
 then  $y_t \in [\mu(y_s) - \varepsilon; \mu(y_s) + \varepsilon]$

-> "generalisable"

# Key questions



1. What are foreseeable needs and new domains of measurements (not currently addressed) and potential tools
  2. Which tools have been developed and applied outside the scope of FIRE experimental facilities: determine missing elements for large-scale experiments on these facilities
  3. Which tools that can be combined (with potential extension) for larger experiments, e.g., multiple STREPs joining efforts and what would be missing to realize larger experiments
  4. Which tools are mature enough to start a basis for re-use by other projects
  5. Identify what can be performed/reached by means of cooperation between projects from a directory of tools accessible to the FIRE community at large up to the joint development of tools (under which conditions, etc.)
- + **Lessons learned and best practices in tools development for measurement-based experimental research**