



**HAL**  
open science

## Monitoring Testbed Experiments with MonEx

Abdulqawi Saif, Alexandre Merlin, Lucas Nussbaum, Ye-Qiong Song

► **To cite this version:**

Abdulqawi Saif, Alexandre Merlin, Lucas Nussbaum, Ye-Qiong Song. Monitoring Testbed Experiments with MonEx. Grid5000-FIT Spring School, SILECS project, INRIA, Apr 2018, Sophia Antipolis, France. hal-01793507

**HAL Id: hal-01793507**

**<https://inria.hal.science/hal-01793507v1>**

Submitted on 16 May 2018

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Monitoring Testbed Experiments with *MonEx*

Abdulqawi Saif<sup>1,2</sup>

Alexandre Merlin<sup>1</sup>

Lucas Nussbaum<sup>1</sup>

Ye-Qiong Song<sup>1</sup>

<sup>1</sup>Université de Lorraine, CNRS, Inria, LORIA, F-54000 Nancy, France

<sup>2</sup>Qwant Entreprise, Épinal, France

April 04, 2018

1<sup>st</sup> Grid'5000-FIT School - Sophia Antipolis, France



## Computer system experiments

- Diversity of environments
- Variety of contexts
- Many kinds of outputs

## Computer system experiments

- Diversity of environments
- Variety of contexts
- Many kinds of outputs

## Experiments' data is often collected via:

- Ad-hoc solutions (*e.g. combining multiple scripts*)
- Manual actions (*e.g. manipulating some missed values*)
- Portability and reproducibility aware-less methods

## Computer system experiments

- Diversity of environments
- Variety of contexts
- Many kinds of outputs

## Experiments' data is often collected via:

- Ad-hoc solutions (*e.g. combining multiple scripts*)
- Manual actions (*e.g. manipulating some missed values*)
- Portability and reproducibility aware-less methods

**How to overcome these challenges?**

## Our aim: having an Experiment Monitoring Framework

- Monitoring?, Yes!, but from experimenters perspective
- Easily collection of experiments' data
- Reducing experimenters effort during experimentation  
*e.g. facilitating analysis by drawing figures*
- Permit to repeat experiment analysis and comparisons

## Open questions:

- What should be targeted by EMFs?
- What needed to build an EMF?
- Do we need to build EMFs from scratch?

## Our aim: having an Experiment Monitoring Framework

- Monitoring?, Yes!, but from experimenters perspective
- Easily collection of experiments' data
- Reducing experimenters effort during experimentation  
*e.g. facilitating analysis by drawing figures*
- Permit to repeat experiment analysis and comparisons

## Open questions:

- What should be targeted by EMFs?
- What needed to build an EMF?
- Do we need to build EMFs from scratch?

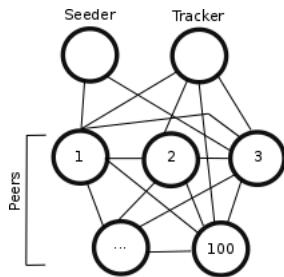


- EMF requirements
- EMF requirements Vs related work
- MonEx EMF design
- Use case experiments of MonEx
- Grid'5000 and MonEx
- Conclusions



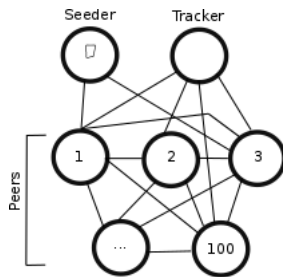
## Motivation experiment

- Target: torrent completion
- 100 peers & one seeder
- Dynamic growth of network  
→ adding a peer after  $n$  sec
- Emulated bandwidth of peers



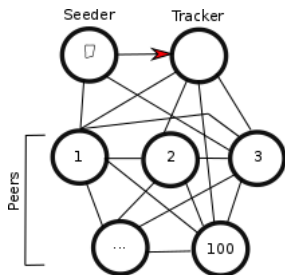
## Motivation experiment

- Target: torrent completion
- 100 peers & one seeder
- Dynamic growth of network  
→ adding a peer after  $n$  sec
- Emulated bandwidth of peers



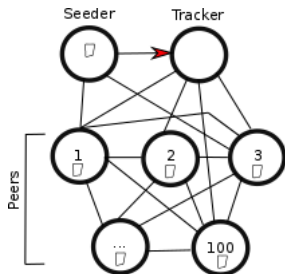
## Motivation experiment

- Target: torrent completion
- 100 peers & one seeder
- Dynamic growth of network  
→ adding a peer after  $n$  sec
- Emulated bandwidth of peers



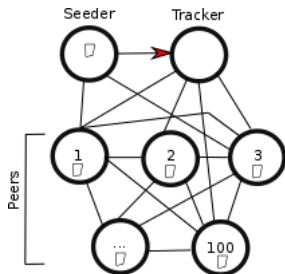
## Motivation experiment

- Target: torrent completion
- 100 peers & one seeder
- Dynamic growth of network  
→ adding a peer after  $n$  sec
- Emulated bandwidth of peers



## Motivation experiment

- Target: torrent completion
- 100 peers & one seeder
- Dynamic growth of network  
→ adding a peer after  $n$  sec
- Emulated bandwidth of peers



## Experiment Monitoring Framework (EMF) requirements

- Experiment-focused
- Independent of experiments
- Independent of testbed services and man. frameworks
- Scalable
- Low impact
- Controllable by users
- Real-time monitoring
- Publishable figures
- Archival of experiments data

# EMF requirements vs related works

---

Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
---	--	-------------	--------

---

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-

[1] Rensfelt, O. et al. Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. et al. ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

**Vendetta** → code modification is necessary

**OML** → def. of measurement points, compilation with OML code,

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.



# EMF requirements vs related works

Vendetta → also a management tool

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

**Inf. mon.** → typical for 5-10 m measurements

**Vendetta** → no info. about the measurement frequency

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

**Inf. mon.** → some with heavy nature (threads, ...)

**Vendetta** → parsing events in-place

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

Testbed-provided services → specific infrastructure

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+
Easy deployment	+	-	+	+

[1] Rensfelt, O. et al. Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. et al. ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

Inf. mon. & Testbed-provided services → only by infrastructure operators

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+
Easy deployment	+	-	+	+
Controllable	-	-	+	+

[1] Rensfelt, O. et al. Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. et al. ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+
Easy deployment	+	-	+	+
Controllable	-	-	+	+
Real-time monitoring	+	+	-	-

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

Inf. mon. & Testbed-provided services → RRDtool

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+
Easy deployment	+	-	+	+
Controllable	-	-	+	+
Real-time monitoring	+	+	-	-
Producing publication-quality figures	-	-	-	-

[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

# EMF requirements vs related works

	Infrastructure monitoring tools e.g. Munin	Testbed-provided measurement services	Vendetta[1]	OML[2]
Experiment-focused	-	-	-	-
Independent of experiments	+	+	-	-
Independent of testbeds services	+	+	-	+
Scalability	+ -	+	+ -	+
Low impact	-	+	-	+
Easy deployment	+	-	+	+
Controllable	-	-	+	+
Real-time monitoring	+	+	-	-
Producing publication-quality figures	-	-	-	-
Archival of data	+	+	-	+

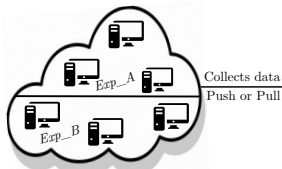
[1] Rensfelt, O. *et al.* Vendetta-a tool for flexible monitoring and management of distributed testbeds. In TridentCom 2007.

[2] Singh, M. *et al.* ORBIT Measurements framework and library (OML) : motivations, implementation and features. In TridentCom 2005.

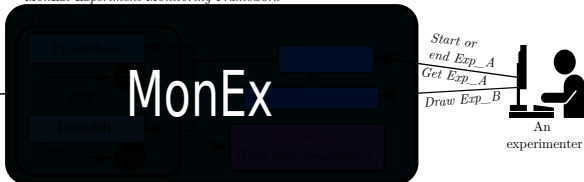


# MonEx EMF (Monitoring Experiments)

Experiments running on a testbed



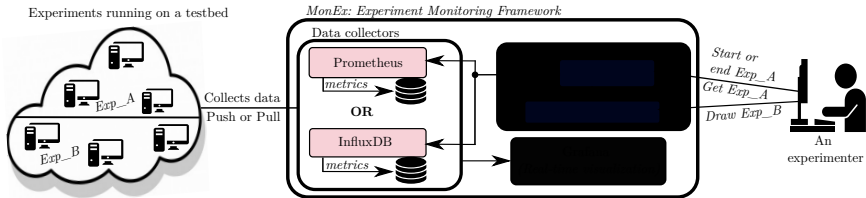
MonEx: Experiment Monitoring Framework



MonEx

Experiment-focused	+
Independent of experiments	+
Independent of testbeds services	+
Scalability	+
Low impact	+
Easy deployment	+
Controllable	+
Real-time monitoring	+
Producing publication-quality figures	+
Archival of data	+

# MonEx EMF (Monitoring Experiments)



	MonEx
Experiment-focused	+
Independent of experiments	+
Independent of testbeds services	+
✓ Scalability	+
✓ Low impact	+
Easy deployment	+
Controllable	+
Real-time monitoring	+
Producing publication-quality figures	+
✓ Archival of data	+

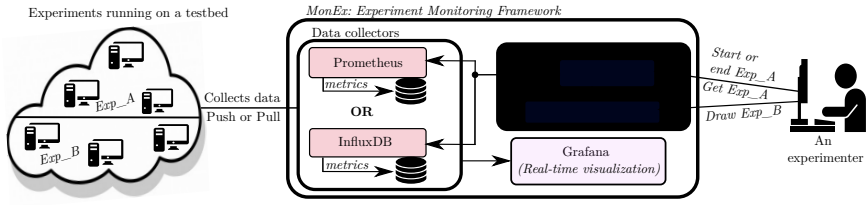
## ■ Prometheus

- Up-to 1 sec as a polling interval 😊
- A lot of **data exporters**  
*e.g. node spec, specific app.*
- Fixed-interval polling 😞

## ■ InfluxDB

- Suitable for **pushing data** 😊
- Variated interval measurements 😊

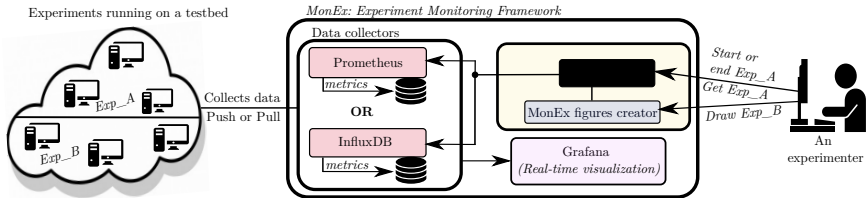
# MonEx EMF (Monitoring Experiments)



## MonEx

- Experiment-focused
- Independent of experiments
- Independent of testbeds services
- ✓ Scalability
- ✓ Low impact
- Easy deployment
- Controllable
- ✓ Real-time monitoring
- Producing publication-quality figures
- ✓ Archival of data

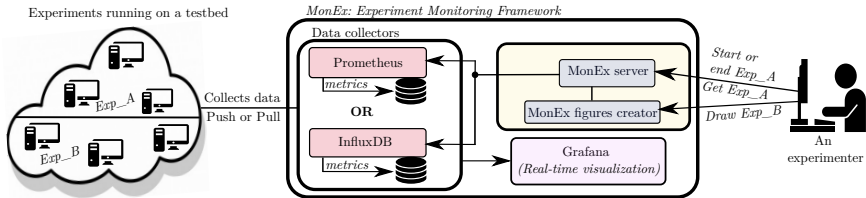
# MonEx EMF (Monitoring Experiments)



	MonEx
Experiment-focused	+
Independent of experiments	+
Independent of testbeds services	+
✓ Scalability	+
✓ Low impact	+
Easy deployment	+
Controllable	+
✓ Real-time monitoring	+
✓ Producing publication-quality figures	+
✓ Archival of data	+

- Create figures that **respect publication aspects**  
e.g. X-Y figures, Y-figures, multiple  
Y-figures, stack figures, ...

# MonEx EMF (Monitoring Experiments)

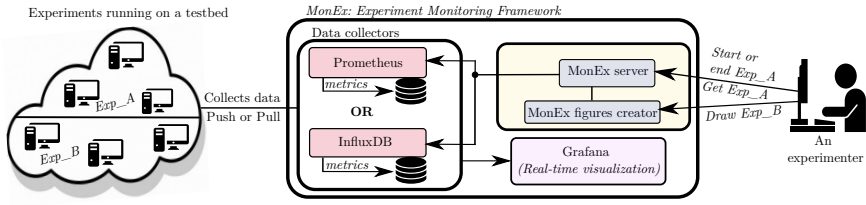


## MonEx

- ✓ Experiment-focused
- Independent of experiments
- Independent of testbeds services
- ✓ Scalability
- ✓ Low impact
- Easy deployment
- ✓ Controllable
- ✓ Real-time monitoring
- ✓ Producing publication-quality figures
- ✓ Archival of data

- Handle experiments by name
- Specify experiment time boundaries
- Allow interacting with experiments metrics

# MonEx EMF (Monitoring Experiments)



---

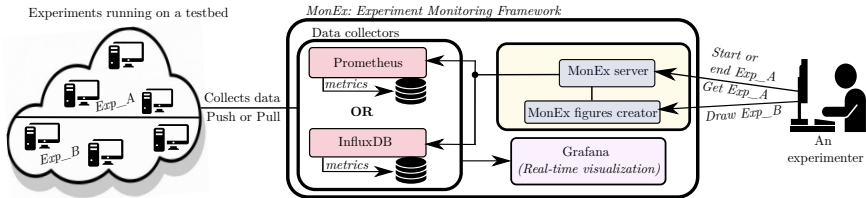
## MonEx

---

- ✓ Experiment-focused
- ✓ Independent of experiments
- ✓ Independent of testbeds services
- ✓ Scalability
- ✓ Low impact
- ✓ Easy deployment
- ✓ Controllable
- ✓ Real-time monitoring
- ✓ Producing publication-quality figures
- ✓ Archival of data



# MonEx EMF (Monitoring Experiments)



## MonEx

- ✓ Experiment-focused
- ✓ Independent of experiments
- ✓ Independent of testbeds services
- ✓ Scalability
- ✓ Low impact
- ✓ Easy deployment
- ✓ Controllable
- ✓ Real-time monitoring
- ✓ Producing publication-quality figures
- ✓ Archival of data

## Experimenter responsibilities:

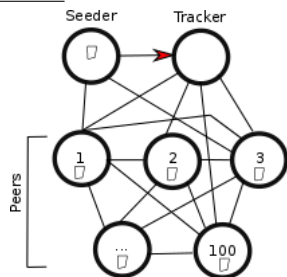
- 1 Make a **usual experiment deployment**
- 2 Communicate data with MonEx
  - Expose it for Prom. or push it into InfluxDB
  - Use or **write your own exporter(s)**

## Three different experiments

- Highlighting MonEx ability to cover EMF requirements
- Performed on the *Grid'5000* testbed

## First Experiment: many-nodes Bittorrent Download

- One seeder & 100 peers
- Transmission as torrent client
- *Distem* for emulating slow peers (30KB/s)
- Dedicated VLAN for monitoring traffic
- Prometheus as a MonEx data collector
- We use our *own exporter*<sup>1</sup> (tens LOC)



[1] [https://github.com/madynes/monex/blob/master/Artifacts\\_and\\_datasets/many-nodes\\_bittorrent/exporter.py](https://github.com/madynes/monex/blob/master/Artifacts_and_datasets/many-nodes_bittorrent/exporter.py)



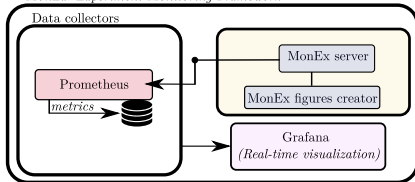
# Use case experiments

## First Experiment: workflow

Bittorrent experiment

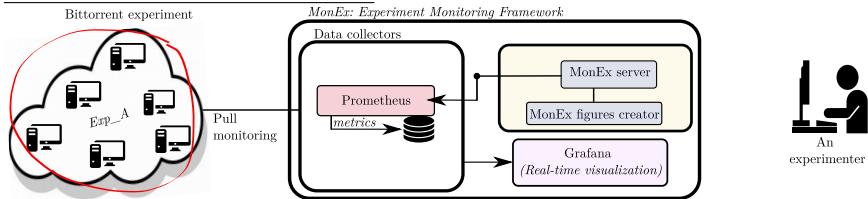


*MonEx: Experiment Monitoring Framework*



# Use case experiments

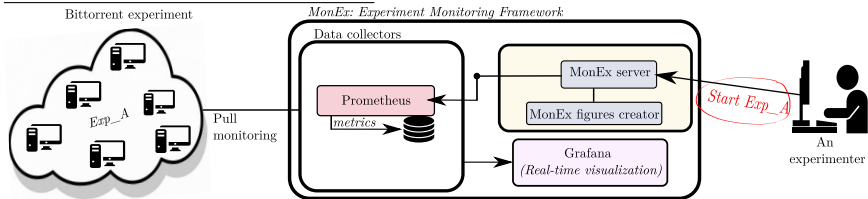
## First Experiment: workflow



**Make a usual deployment and install *MonEx***

# Use case experiments

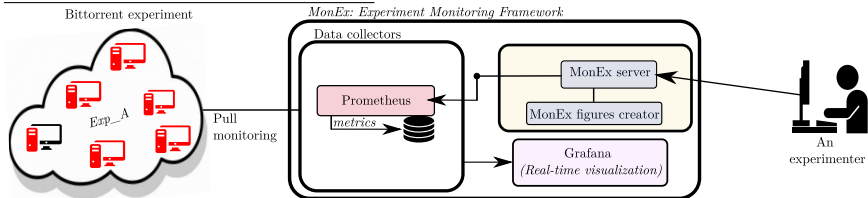
## First Experiment: workflow



```
curl -X POST MonEx_IP:5000/exp/Exp_A
```

# Use case experiments

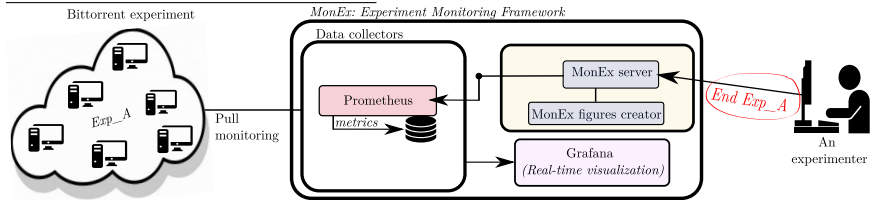
## First Experiment: workflow



Run experiments' workload

# Use case experiments

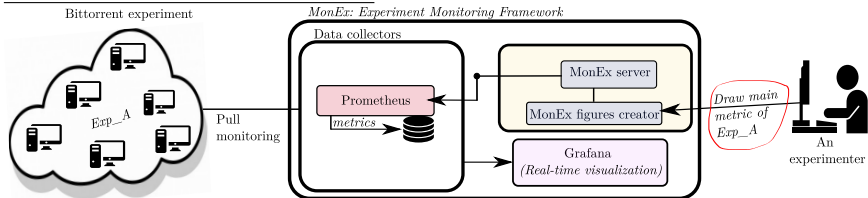
## First Experiment: workflow



```
curl -X PUT MonEx_IP:5000/exp/Exp_A
```

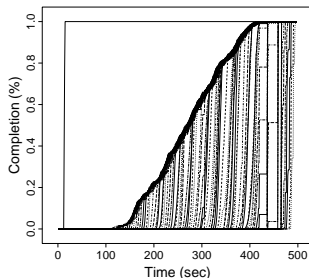
# Use case experiments

## First Experiment: workflow



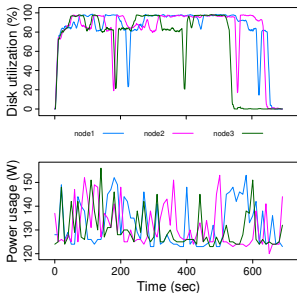
```
./monex-draw -S M_IP:5000 -exp  
"Exp_A" -metric "completion" -type  
"duration" -t "Torrent ..." -y  
"Completion (%)" -x "Time (sec)" -n
```

Torrent completion of a 500MBytes file  
over time on a 30 kBytes/s network



## Second Experiment: metrics diversity

- Metrics: **HDD Util & power** of a *MongoDB* cluster
- Three-shard nodes & 80 GB of total data
- **Prometheus** as a data collector & **Grafana** for visualization
- **Two default node-exporters** of Prometheus
  - ⇒ node-exporter → nodes spec.
  - ⇒ SNMP-exporter → PDUs data



## Third Experiment: time-dependent & heavy-measurement

- Metric : file offsets vs sequences of I/O requests
- High-frequency measurement (thousands of I/O)  
→ pushing data to InfluxDB
- Generate I/O traces using an eBPF tool
- Fio benchmark generates rand. read workload

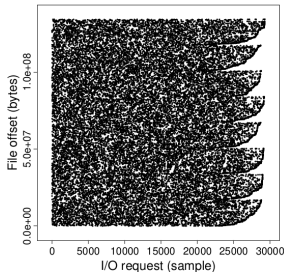
## Third Experiment: results

### ■ Get data

```
curl -X GET 127.1:5000/exp/accessPattern -H  
"Content-Type: application/json" -d  
'"measurement": "ebpf", "server": "influx",  
"database": "monex", "type": "sample"' > d.csv
```

### ■ Draw-it!

```
./monex-draw -F d.csv -x "I/O request  
(sample)" -y "Offset (bytes)" -p -r "random"
```





## MonEx leverages several features of Grid'5000:

- Monitoring traffic on separate LAN or another NIC
  - Targeting scalable experiments  
*e.g. torrent experiment*
- Up-to-date docs and rich API  
*e.g. We automated the power experiment thanks to a Grid'5000 wiki page*
- Co-operating easily with outside environment  
*e.g. placing MonEx outside the testbed*
- Deploying customized images with root privileges  
*e.g. with built-in node-exporters*

## Conclusions:

- We defined the **minimal requirements of EMFs**
- **Absence** of related work with full coverage of requirements
- We designed **MonEx EMF** on top of Prometheus and InfluxDB monitoring systems
  - Usable on various experimentations' context
  - Efficient for analysis repetition and metrics comparisons
  - First step to **unifying** experiments' data collection methods
  - Towards **experiments portability** and reproducibility

## Future prospects:

- MonEx maturity?
- Monitoring experiments on federated testbeds

# Any Questions ?

## Conclusions:

- We defined the **minimal requirements of EMFs**
- **Absence** of related work with full coverage of requirements
- We designed **MonEx EMF** on top of Prometheus and InfluxDB monitoring systems
  - Usable on various experimentations' context
  - Efficient for analysis repetition and metrics comparisons
  - First step to **unifying** experiments' data collection methods
  - Towards **experiments portability** and reproducibility

## Future prospects:

- MonEx maturity?
- Monitoring experiments on federated testbeds

# Any Questions ?