



## Monitoring Testbed Experiments with MonEx

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# 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

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- Variety of contexts
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## 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

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- Many kinds of outputs

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- 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?

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## Open questions:

- What should be targeted by EMFs?
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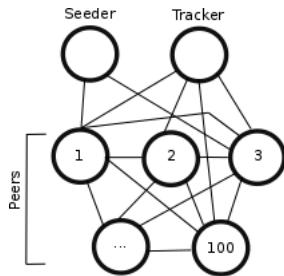


- EMF requirements
- EMF requirements Vs related work
- MonEx EMF design
- Use case experiments of MonEx
- Grid'5000 and MonEx
- Conclusions



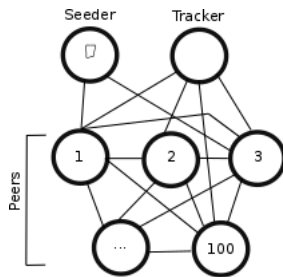
## Motivation experiment

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



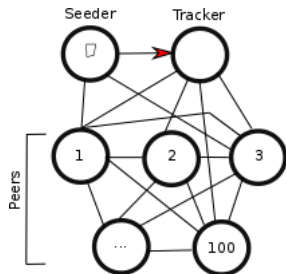
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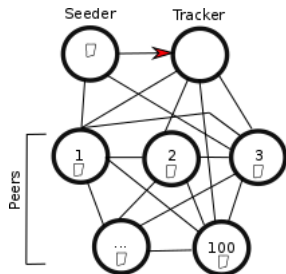
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## Motivation experiment

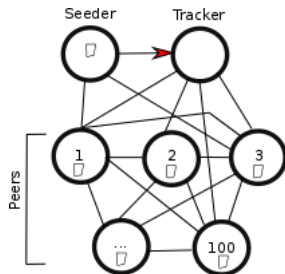
- Target: torrent completion
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- Dynamic growth of network  
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# EMF requirements

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

# EMF requirements vs related works

| Infrastructure monitoring<br>tools e.g. Munin | Testbed-provided<br>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.

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|--------------------|---|--|-------------|--------|
| Experiment-focused | -   | -  | -           | -      |

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# EMF requirements vs related works

**Vendetta** → code modification is necessary

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

OML code,

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

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# EMF requirements vs related works

Vendetta → also a management tool

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

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# EMF requirements vs related works

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

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

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

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# EMF requirements vs related works

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

**Vendetta** → parsing events in-place

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

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# 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                  | +  | -                                     | +           | +      |

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# 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                     | -  | -                                     | +           | +      |

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| Independent of experiments       | +   | +  | -           | -      |
| Independent of testbeds services | +   | +  | -           | +      |
| Scalability                      | + -   | +  | + -         | +      |
| Low impact                       | -   | +  | -           | +      |
| Easy deployment                  | +   | -  | +           | +      |
| Controllable                     | -   | -  | +           | +      |
| Real-time monitoring             | +   | +  | -           | -      |

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# EMF requirements vs related works

Inf. mon. & Testbed-provided services → RRDtool

|                                       | Infrastructure monitoring<br>tools e.g. Munin | Testbed-provided<br>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 | -   | -  | -           | -      |

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# EMF requirements vs related works

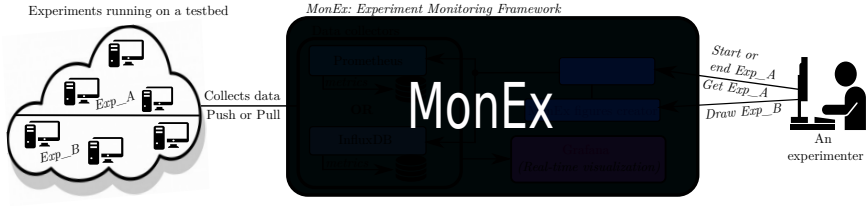
|                                       | Infrastructure monitoring<br>tools e.g. Munin | Testbed-provided<br>measurement services | Vendetta[1] | OML[2] |
|---------------------------------------|---|--|-------------|--------|
| Experiment-focused                    | -   | -  | -           | -    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

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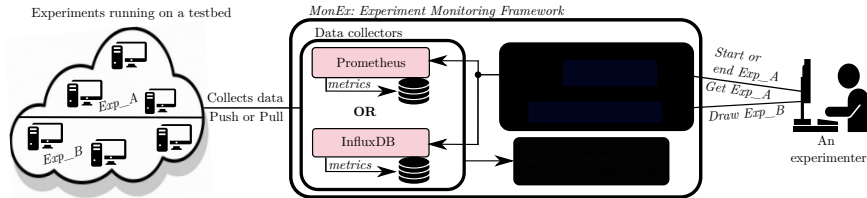


# MonEx EMF (Monitoring Experiments)



|                                       | 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                    | +     |

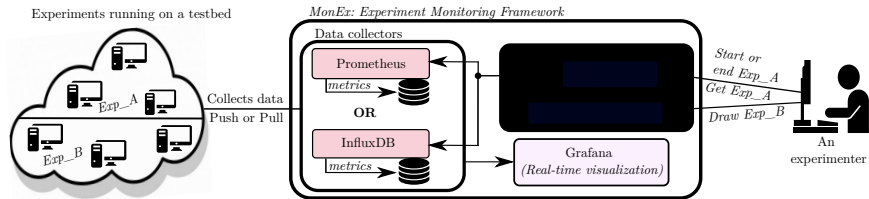
## ■ Prometheus

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

## ■ InfluxDB

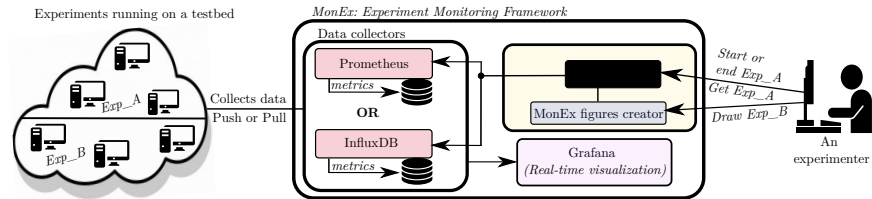
- Suitable for **pushing data** 😊
- Variated interval measurements 😊

# 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                    | +     |

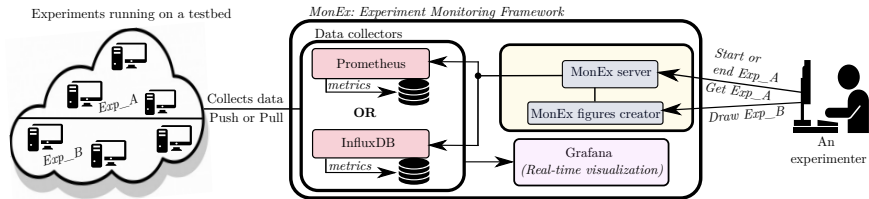
# MonEx EMF (Monitoring Experiments)



|   | 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, ...

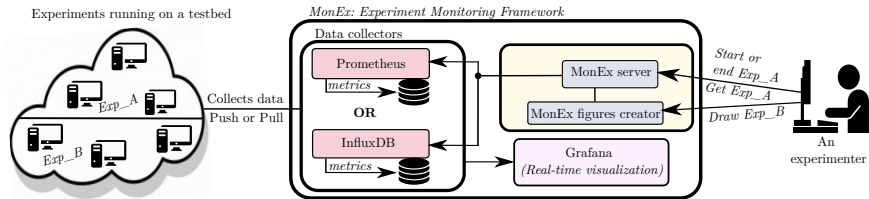
# MonEx EMF (Monitoring Experiments)



|   | MonEx |
|---|-------|
| ✓ Experiment-focused                    | +     |
| Independent of experiments              | +     |
| Independent of testbeds services        | +     |
| ✓ Scalability                           | +     |
| ✓ Low impact                            | +     |
| Easy deployment                         | +     |
| ✓ Controllable                          | +     |
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| ✓ Archival of data                      | +     |

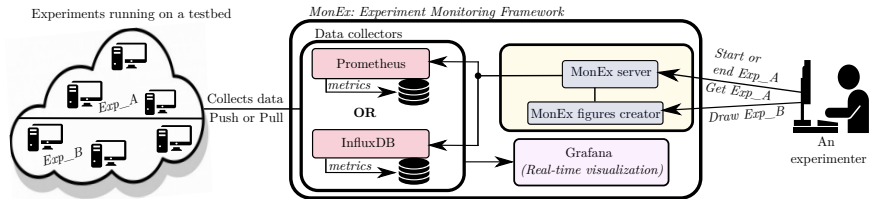
- Handle experiments **by name**
- Specify experiment **time boundaries**
- Allow **interacting with experiments metrics**

# 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)

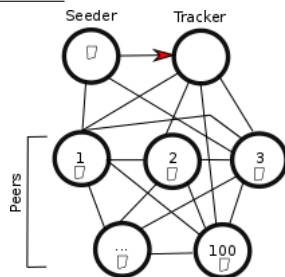
# Use case experiments

## 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)



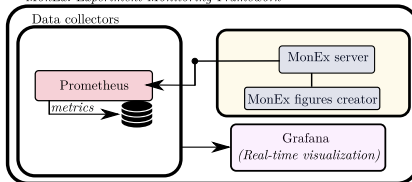
# Use case experiments

## First Experiment: workflow

Bittorrent experiment

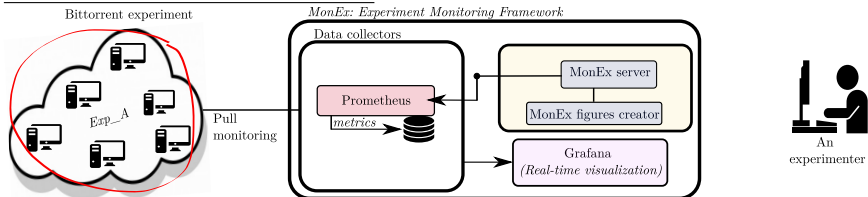


*MonEx: Experiment Monitoring Framework*



# Use case experiments

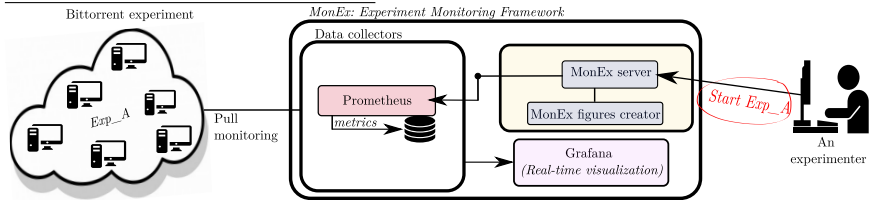
## First Experiment: workflow



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

# Use case experiments

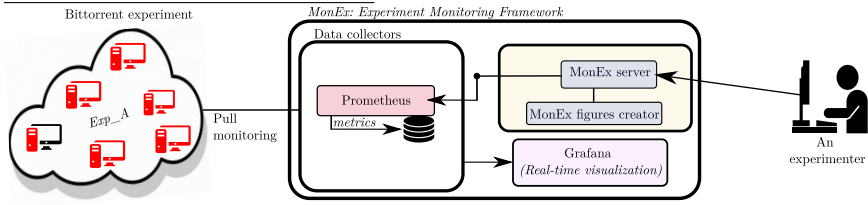
## First Experiment: workflow



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

# Use case experiments

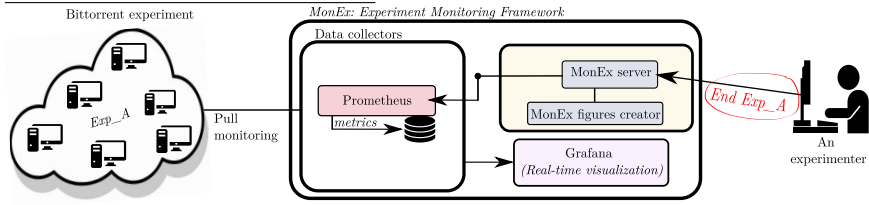
## First Experiment: workflow



Run experiments' workload

# Use case experiments

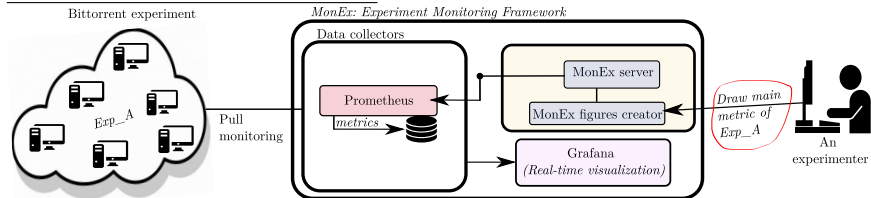
## First Experiment: workflow



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

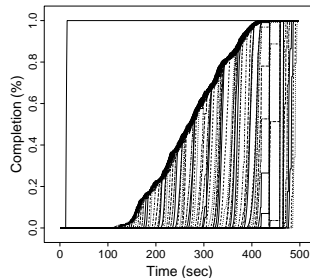
# Use case experiments

## First Experiment: workflow



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

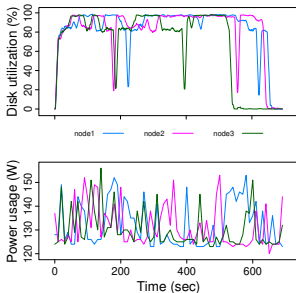
Torrent completion of a 500MBytes file  
over time on a 30 kBytes/s network



# Use case experiments

## 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

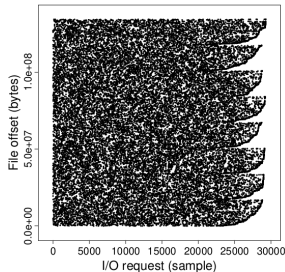
## Third Experiment: results

- 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 ?