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► 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

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Submitted on 16 May 2018

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Monitoring Testbed Experiments with *MonEx*

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April 04, 2018

1st Grid'5000-FIT School - Sophia Antipolis, France



Computer system experiments

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

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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

Computer system experiments

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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

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:

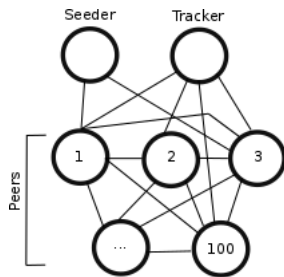
- What should be targeted by EMFs?
- What needed to build an EMF?
- Do we need to build EMFs from scratch?



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

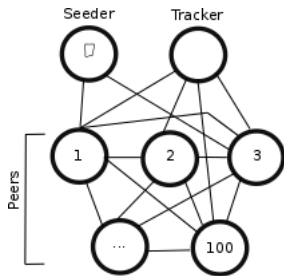
Motivation experiment

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



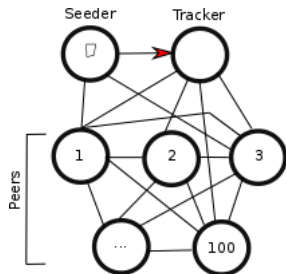
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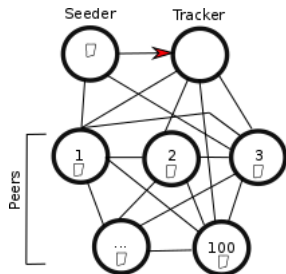
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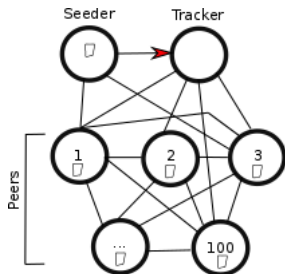
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- Dynamic growth of network
→ adding a peer after n sec
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EMF requirements

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

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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 tools e.g. Munin	Testbed-provided 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 tools e.g. Munin	Testbed-provided 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 tools e.g. Munin	Testbed-provided 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 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.

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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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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	+	+	-	-

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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	-	-	-	-

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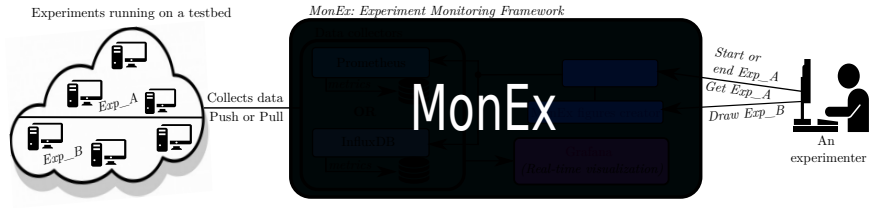
EMF requirements vs related works

	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	+	+	-	+

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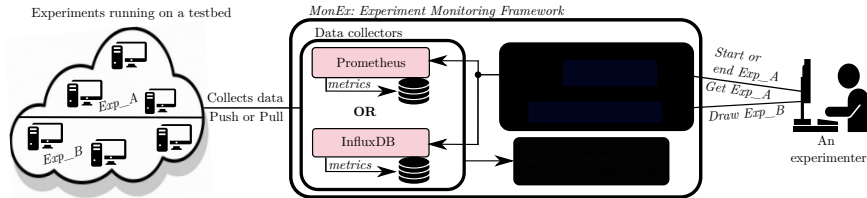
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MonEx EMF (Monitoring Experiments)



	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	+

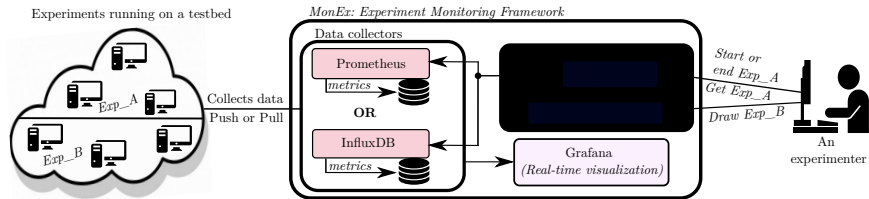
■ Prometheus

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

■ InfluxDB

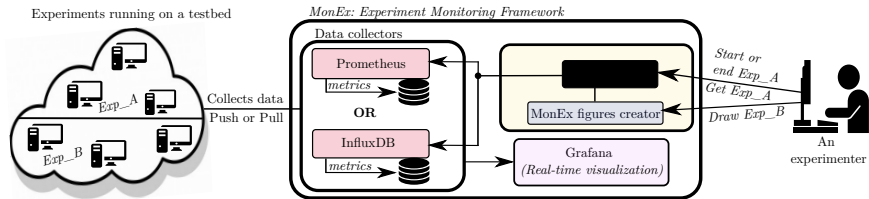
- Suitable for **pushing data** ☺
- Variated interval measurements ☺

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	+

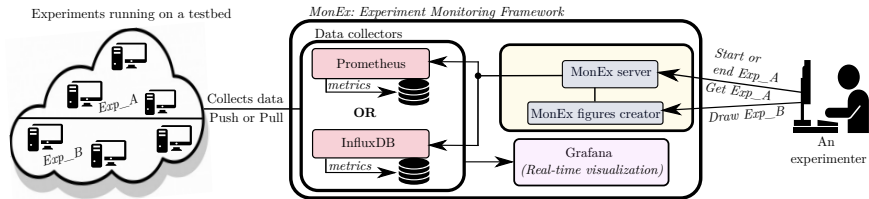
MonEx EMF (Monitoring Experiments)



	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, ...

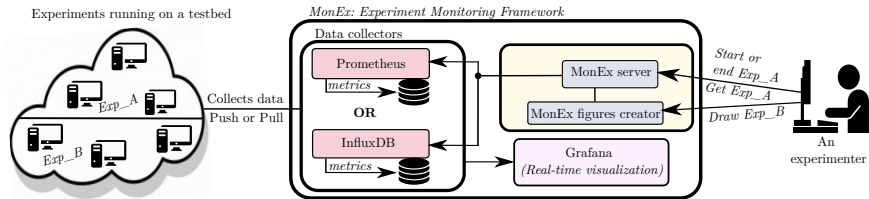
MonEx EMF (Monitoring Experiments)



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

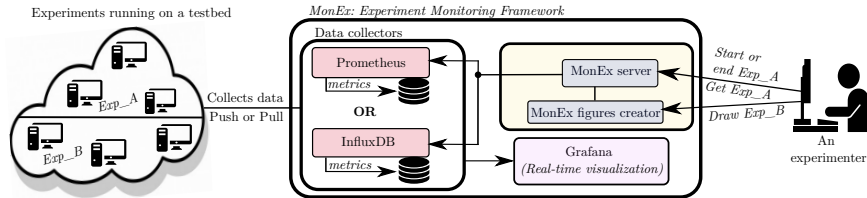
- Handle experiments **by name**
- Specify experiment **time boundaries**
- Allow **interacting with experiments metrics**

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)

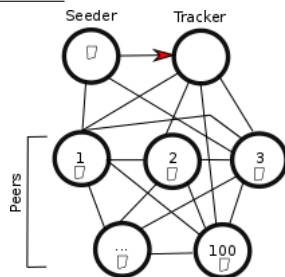
Use case experiments

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*¹ (tens LOC)



[1] https://github.com/madynes/monex/blob/master/Artifacts_and_datasets/many-nodes_bittorrent/exporter.py

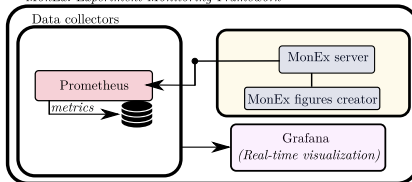
Use case experiments

First Experiment: workflow

Bittorrent experiment

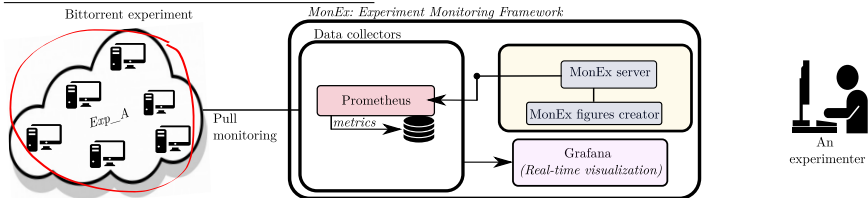


MonEx: Experiment Monitoring Framework



Use case experiments

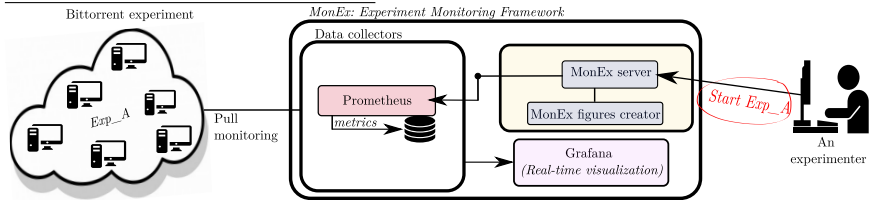
First Experiment: workflow



Make a usual deployment and install *MonEx*

Use case experiments

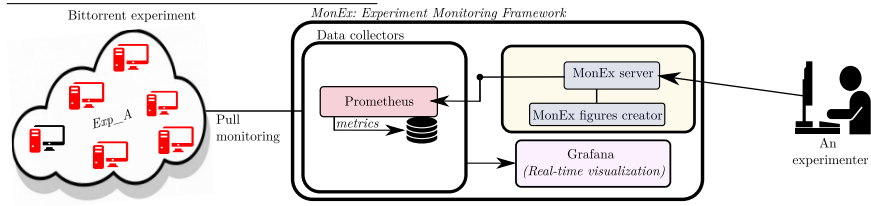
First Experiment: workflow



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

Use case experiments

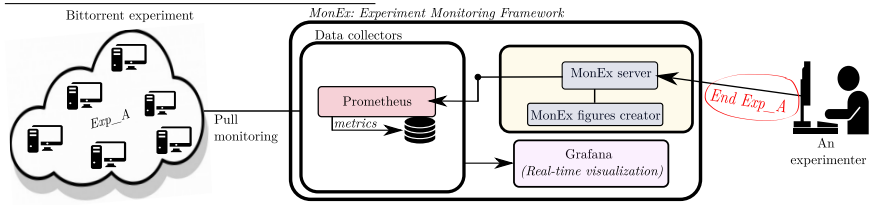
First Experiment: workflow



Run experiments' workload

Use case experiments

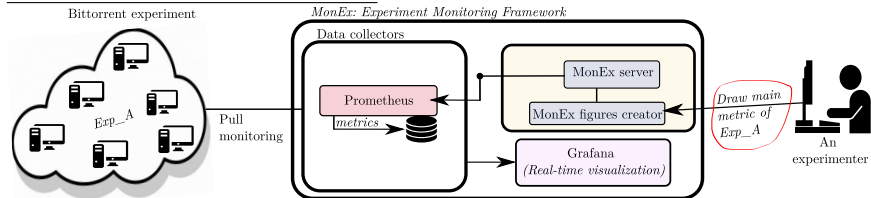
First Experiment: workflow



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

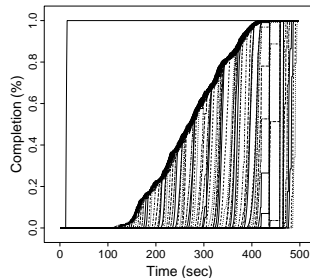
Use case experiments

First Experiment: workflow



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

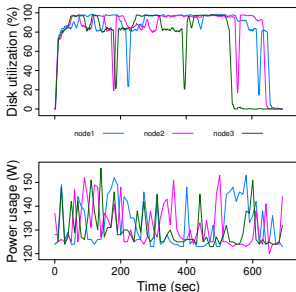
Torrent completion of a 500MBytes file
over time on a 30 kBytes/s network



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

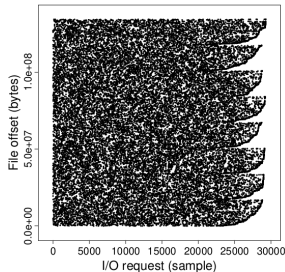
Third Experiment: results

- 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 ?

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