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# Monitoring Testbed Experiments with *MonEx*

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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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- 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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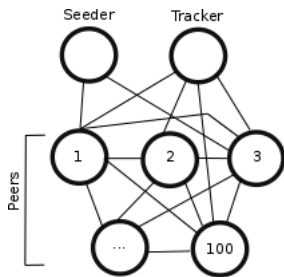


- EMF requirements
- EMF requirements Vs related work
- MonEx EMF design
- Use case experiments of MonEx
- Grid'5000 and MonEx
- Conclusions



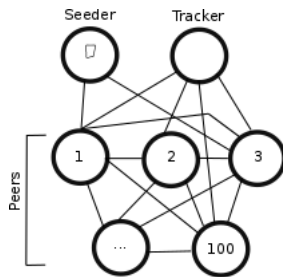
## Motivation experiment

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



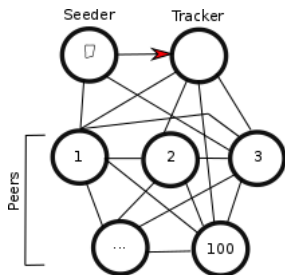
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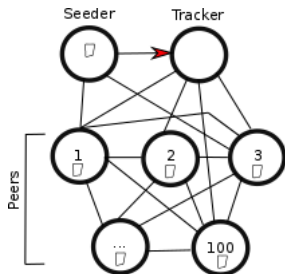
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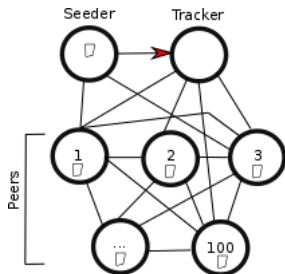
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## Experiment Monitoring Framework (EMF) requirements

- 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

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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.

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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	+	-	+	+

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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	+	+	-	+

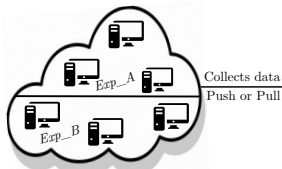
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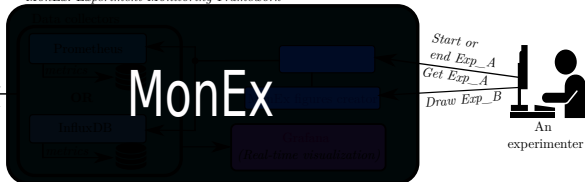


# MonEx EMF (Monitoring Experiments)

Experiments running on a testbed

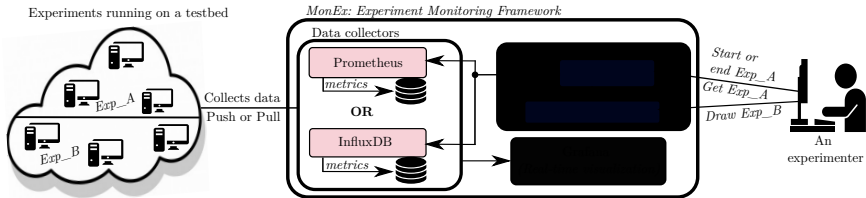


MonEx: Experiment Monitoring Framework



	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	+

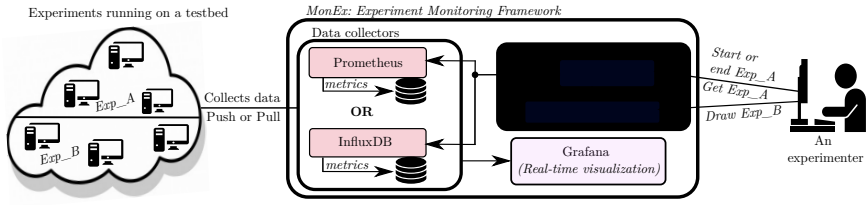
## ■ Prometheus

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

## ■ InfluxDB

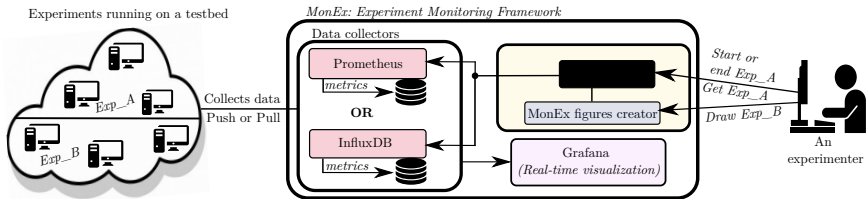
- Suitable for **pushing data** 😊
- Variated interval measurements 😊

# 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	+

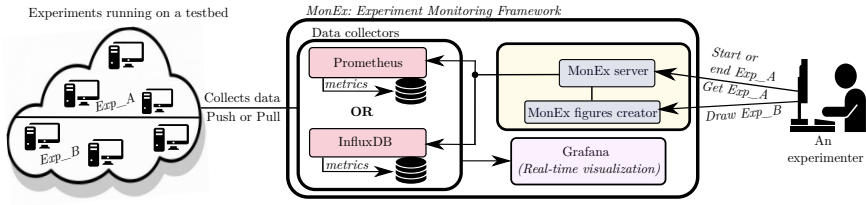
# MonEx EMF (Monitoring Experiments)



	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)

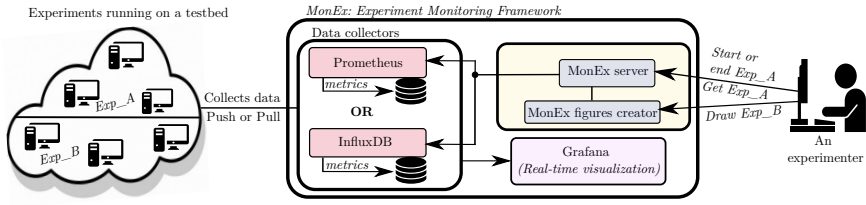


## MonEx

- ✓ 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)



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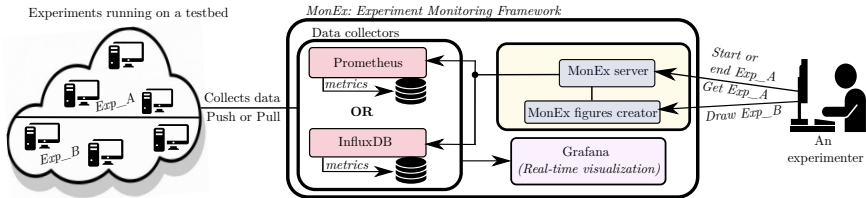
## MonEx

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# MonEx EMF (Monitoring Experiments)



## MonEx

- ✓ Experiment-focused
- ✓ Independent of experiments
- ✓ Independent of testbeds services
- ✓ Scalability
- ✓ Low impact
- ✓ Easy deployment
- ✓ Controllable
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- ✓ Producing publication-quality figures
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## Experimenter responsibilities:

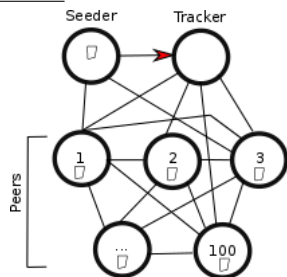
- 1 Make a **usual experiment deployment**
- 2 Communicate data with MonEx
  - Expose it for Prom. or push it into InfluxDB
  - Use or **write your own exporter(s)**

## 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)



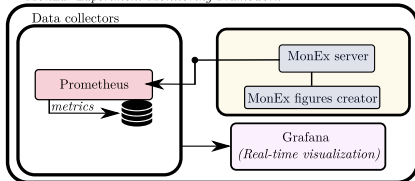
# Use case experiments

## First Experiment: workflow

Bittorrent experiment

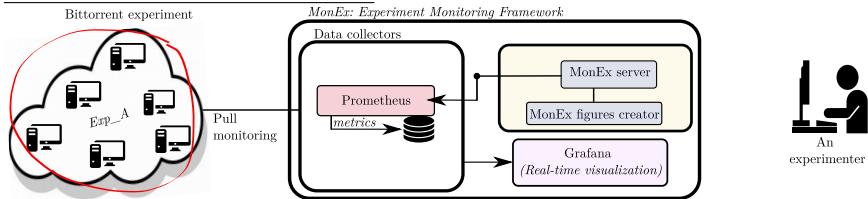


*MonEx: Experiment Monitoring Framework*



# Use case experiments

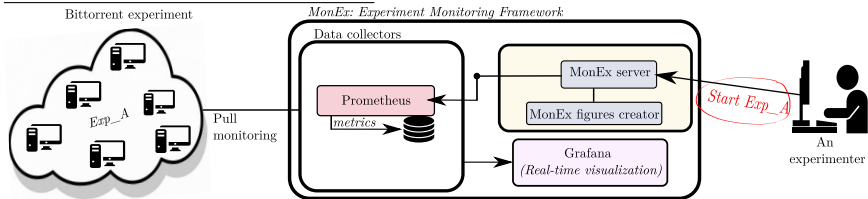
## First Experiment: workflow



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

# Use case experiments

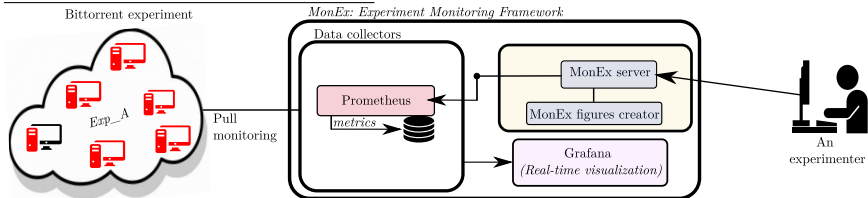
## First Experiment: workflow



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

# Use case experiments

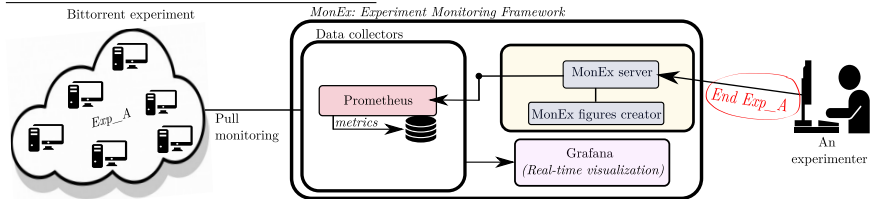
## First Experiment: workflow



Run experiments' workload

# Use case experiments

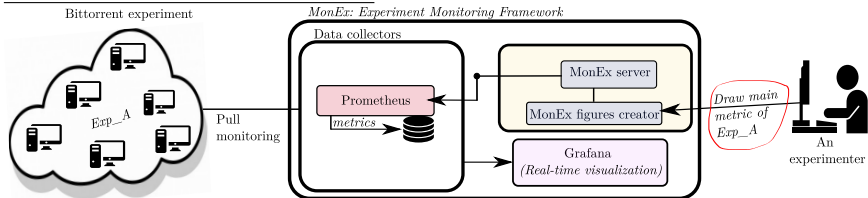
## First Experiment: workflow



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

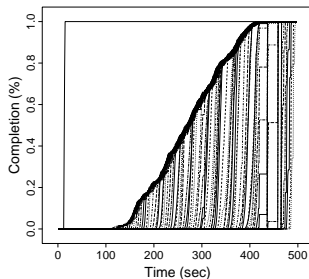
# Use case experiments

## First Experiment: workflow



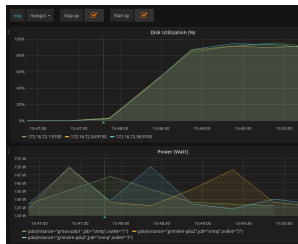
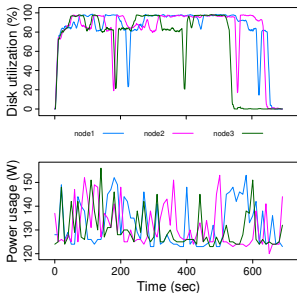
```
./monex-draw -S M_IP:5000 -exp  
"Exp_A" -metric "completion" -type  
"duration" -t "Torrent ..." -y  
"Completion (%)" -x "Time (sec)" -n
```

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

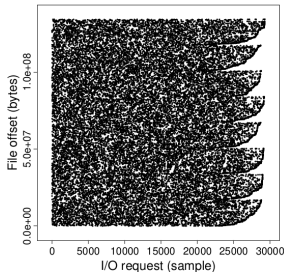
## Third Experiment: results

### ■ 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 ?

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