Internet topology dynamics in ten minutes

Sergey Kirgizov under the supervision of Clémence Magnien

Complex Networks $\subset$ LIP6 $\subset$ (UPMC $\times$ CNRS)

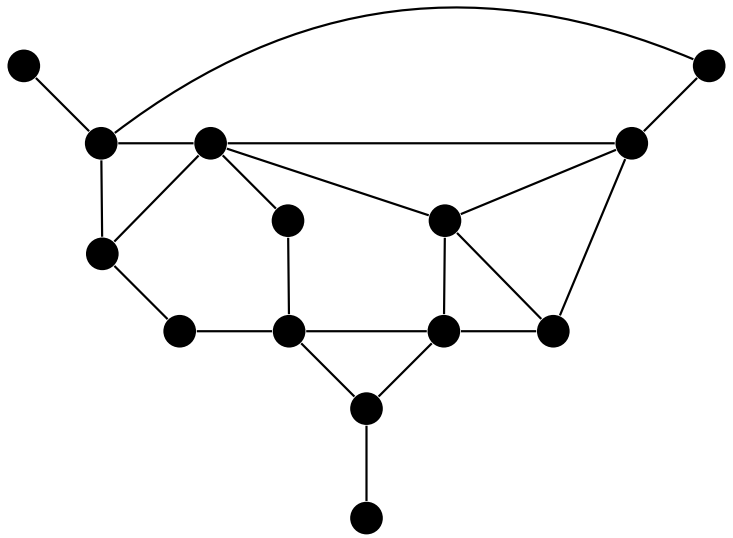
4 March 2014

Outline

1. What do we observe?
2. Why it is so important?
3. How do we study our observations?

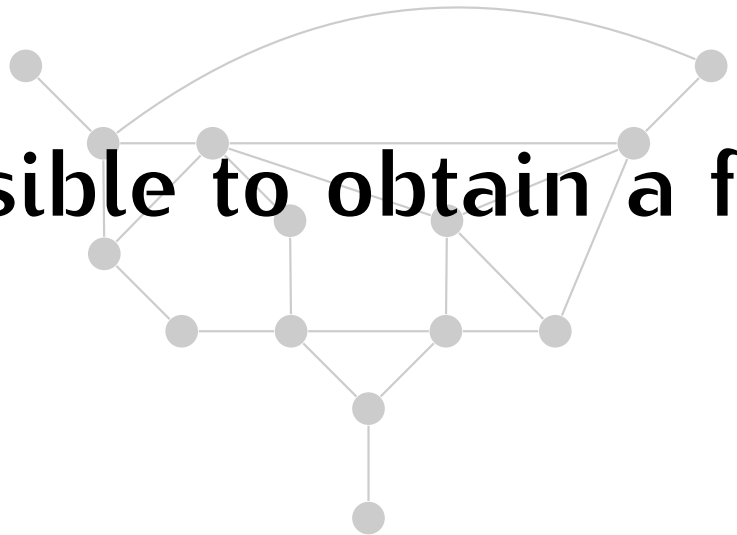
What do we observe?

Internet IP-level topology



Nodes: IP addresses
Links: connections between hosts

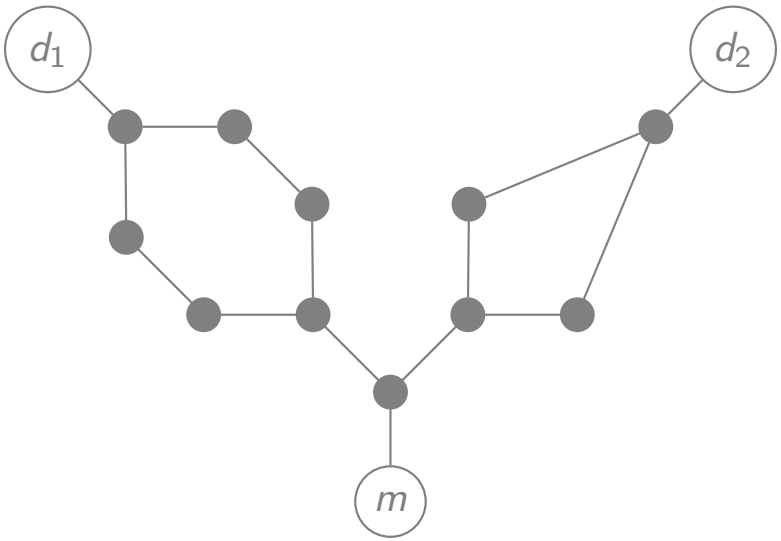
Internet IP-level topology



Impossible to obtain a full map

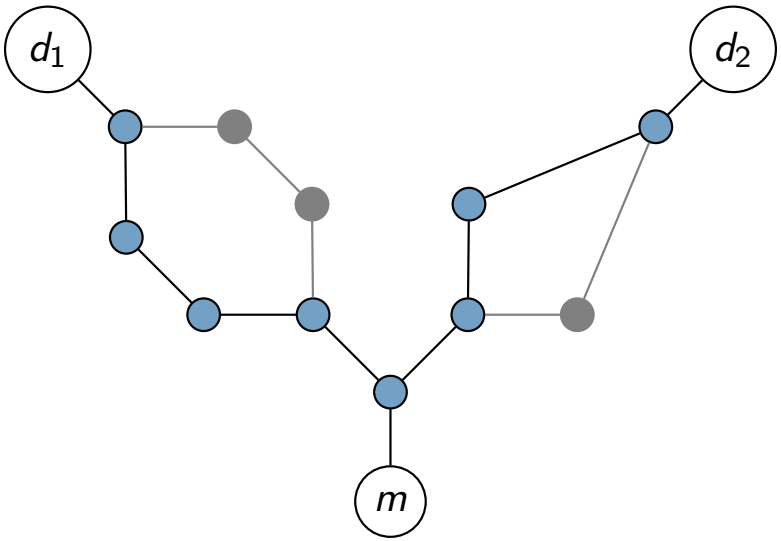
Nodes: IP addresses
Links: connections between hosts

Ego-centered views



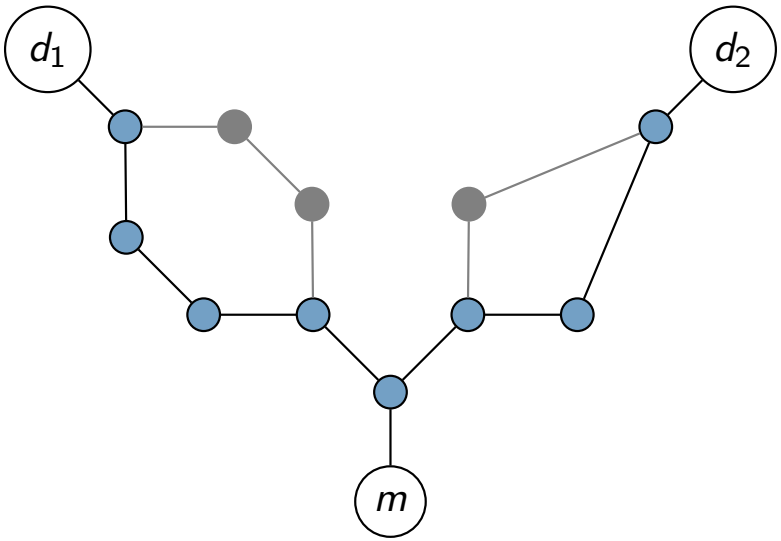
(shortest) paths between **monitor** and **destinations**

Ego-centered views



a measurement by `tracetree`

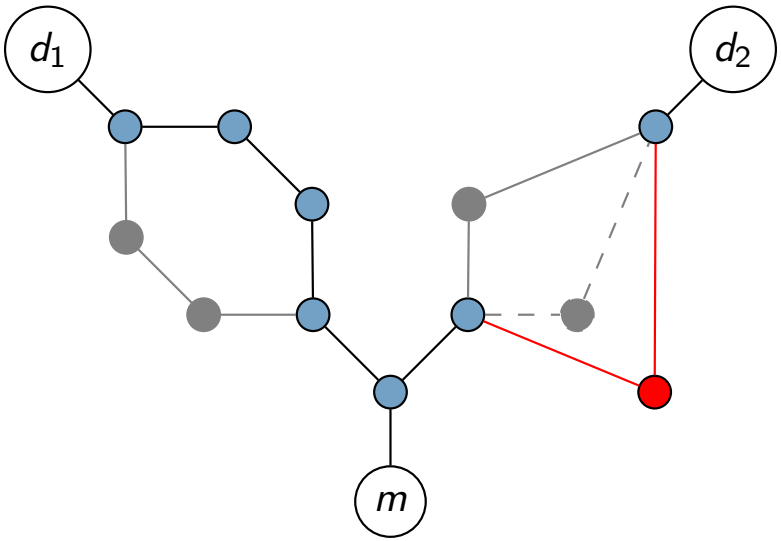
Ego-centered views



another measurement by `tracetree`

load-balancing

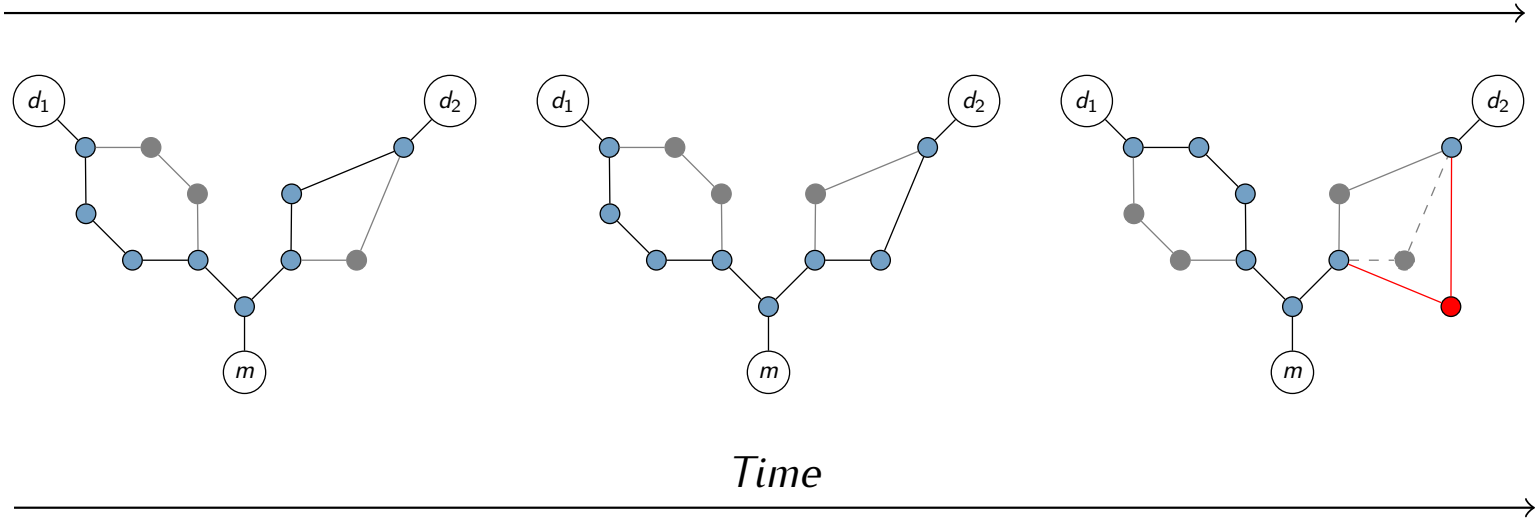
Ego-centered views



yet another measurement by `tracetree`

evolution of routes

Ego-centered view dynamics



Fast periodic measurements $\Longrightarrow$ **study of the dynamics**

Why we should study this?

Some possible applications

- Develop a good model of the network
- Security (unstable routes means more spyware?)
- Robustness of the network and protocols
- Event detection
- Web caching
- *etc*

Can we *see* the dynamics?

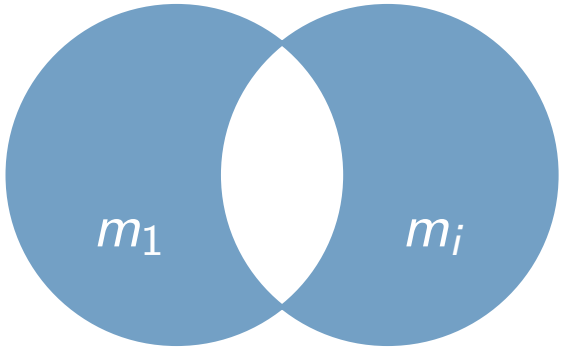
Evolution of symmetric difference between measurements (one destination)

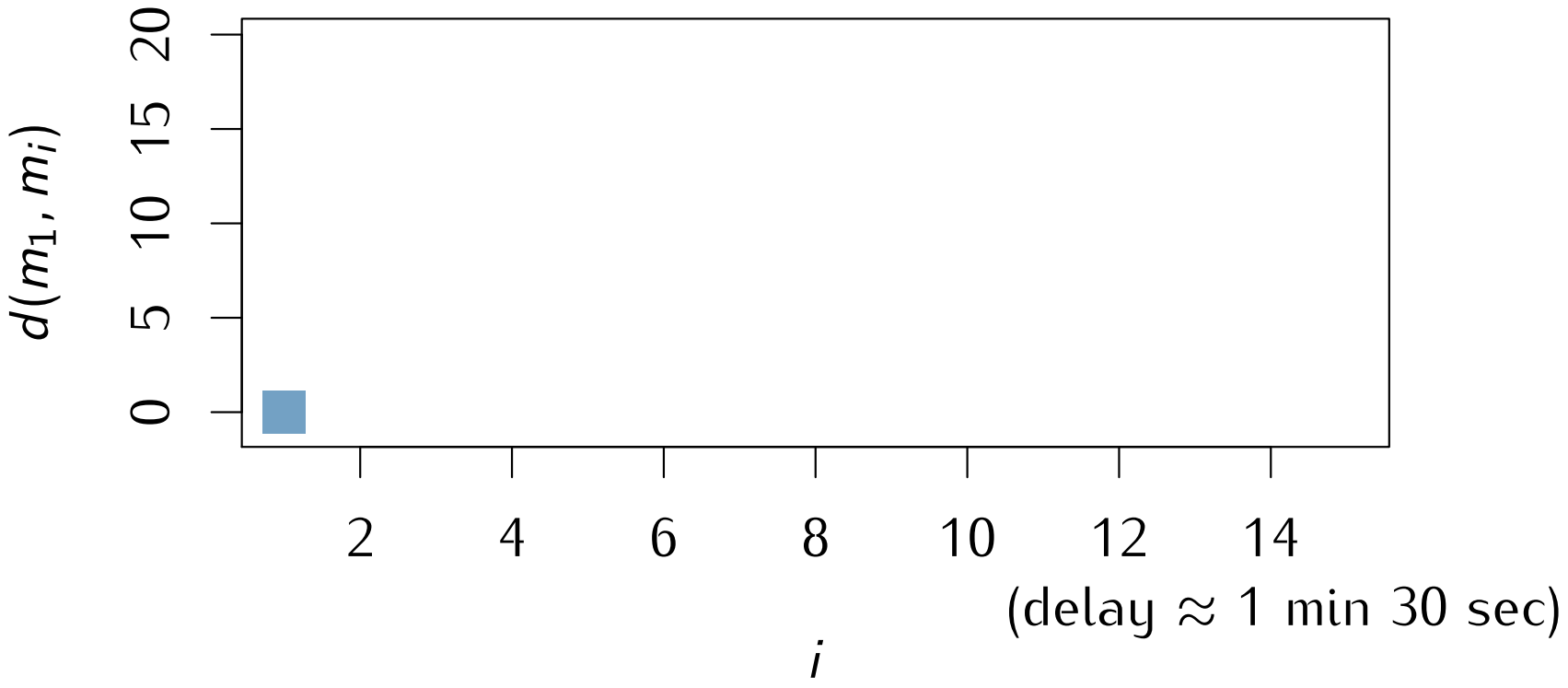
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





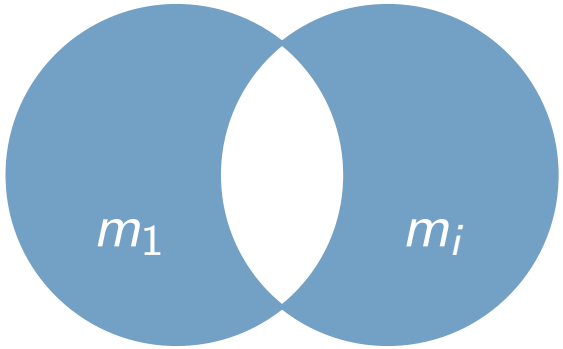
Evolution of symmetric difference between measurements (one destination)

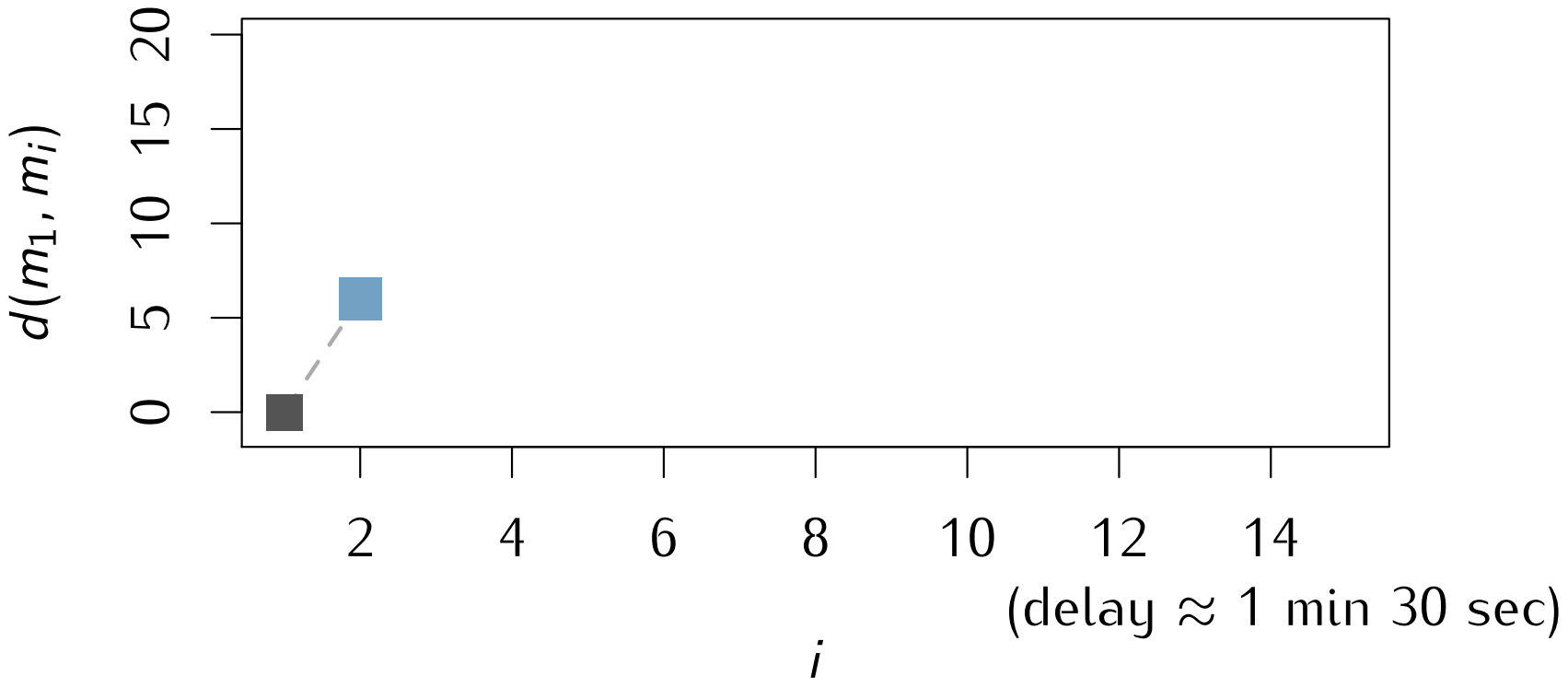
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





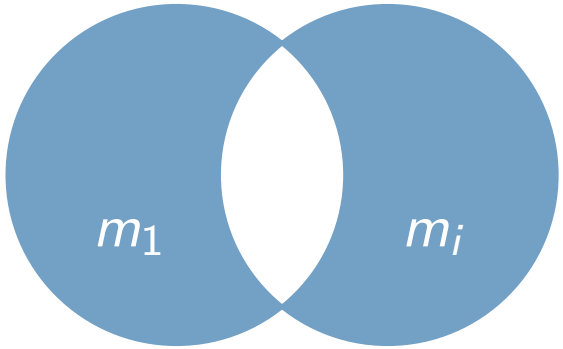
Evolution of symmetric difference between measurements (one destination)

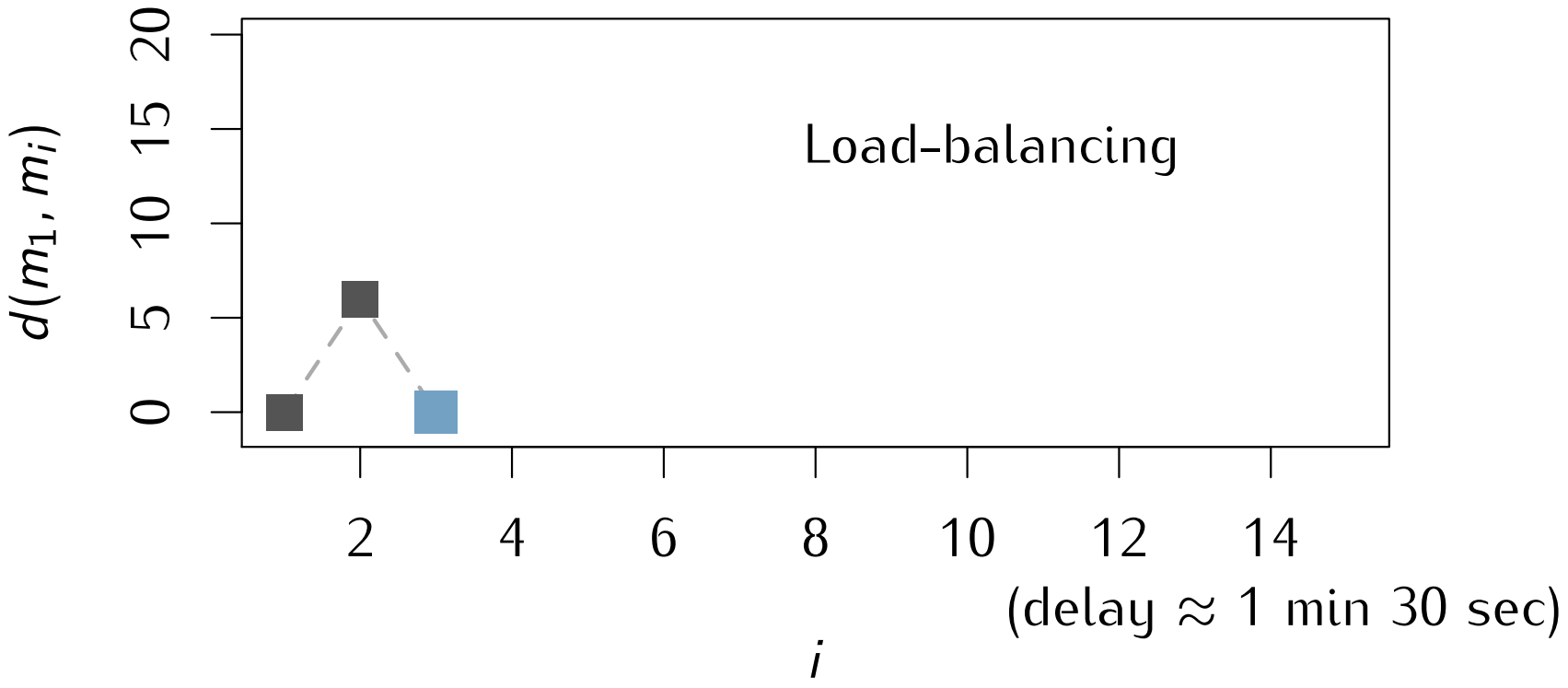
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





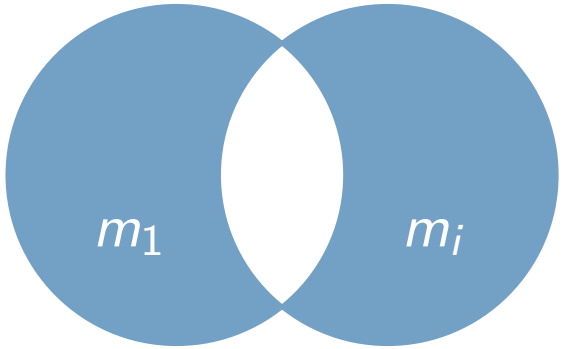
Evolution of symmetric difference between measurements (one destination)

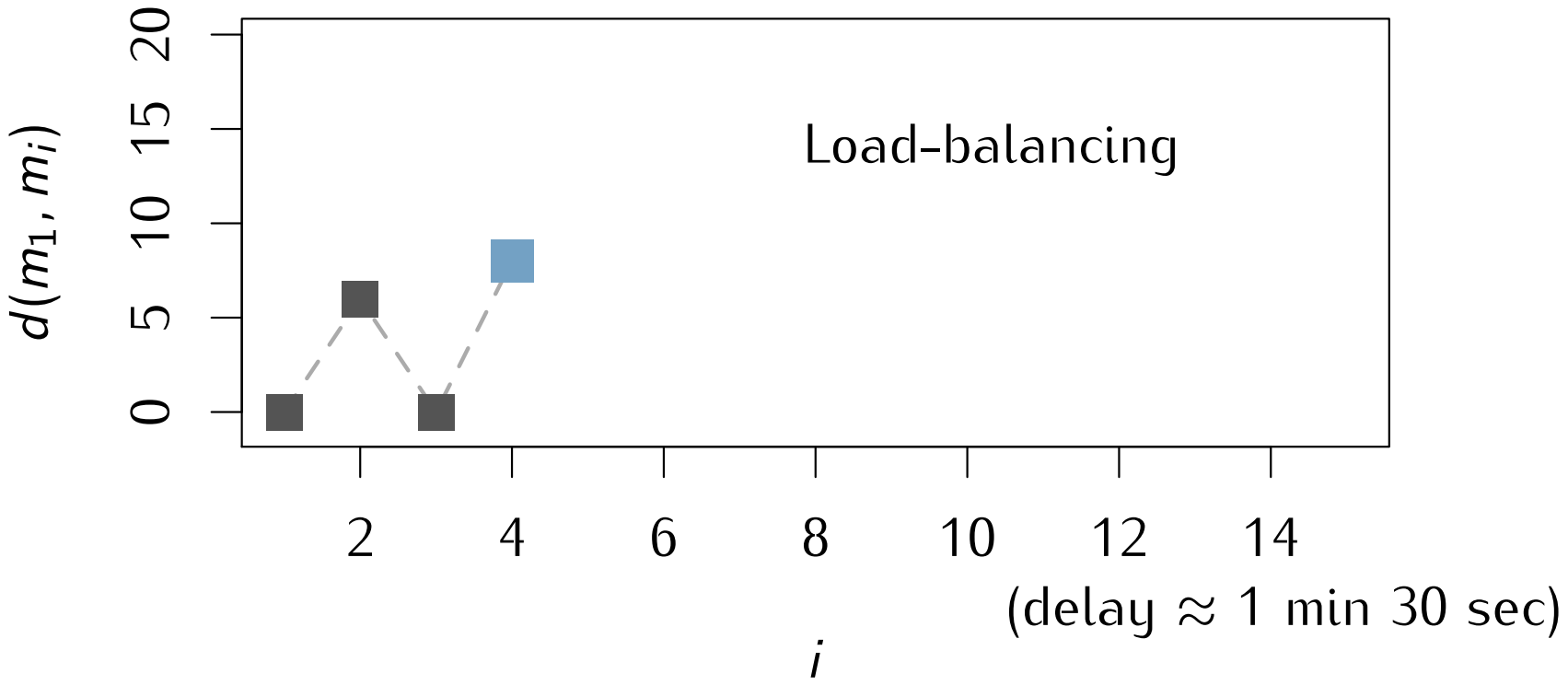
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





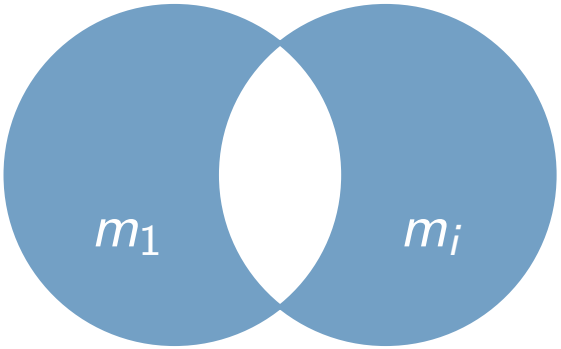
Evolution of symmetric difference between measurements (one destination)

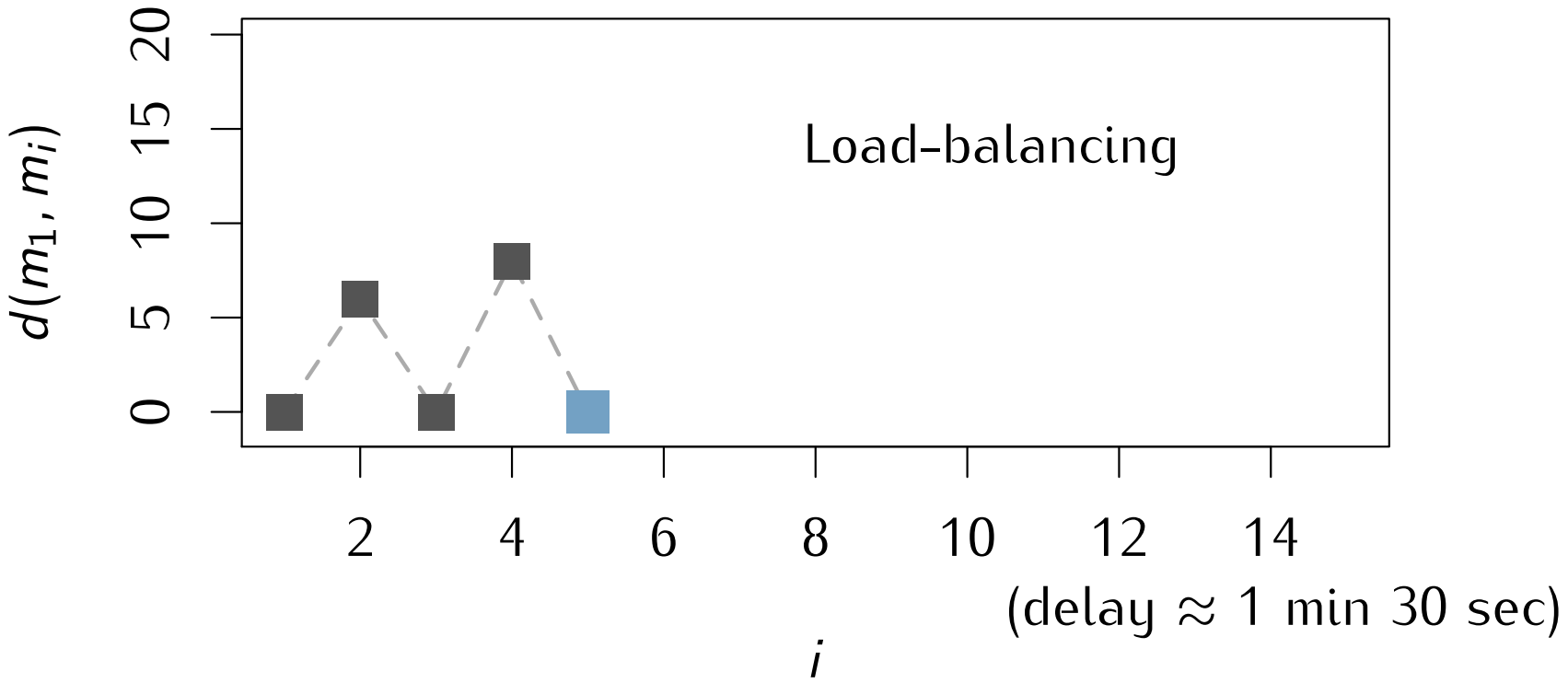
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





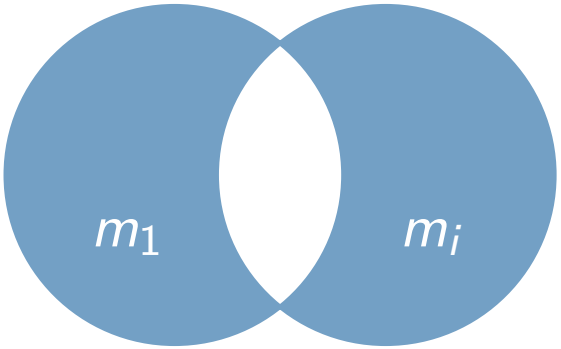
Evolution of symmetric difference between measurements (one destination)

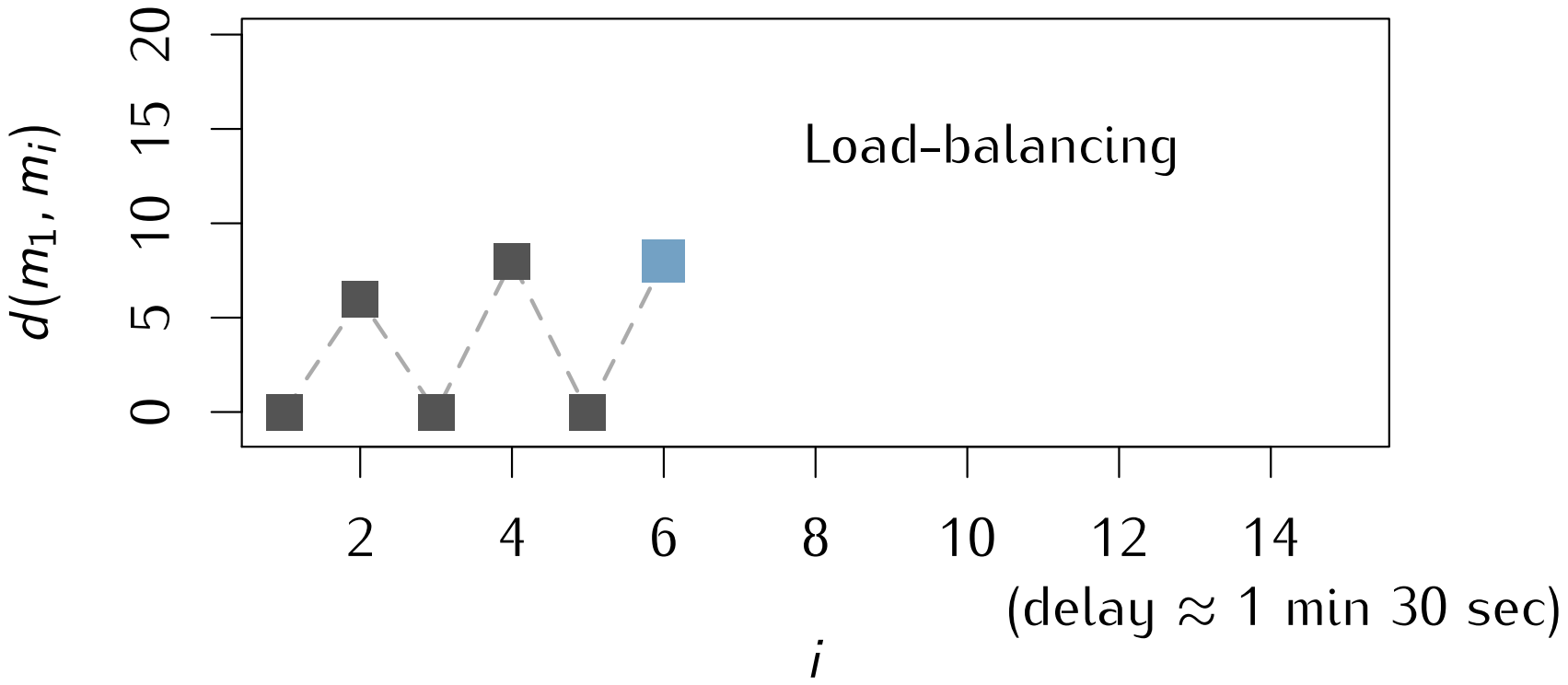
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





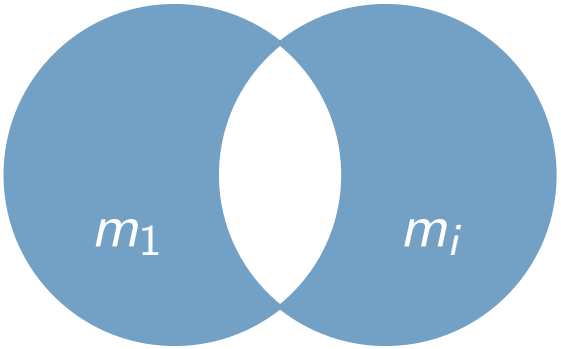
Evolution of symmetric difference between measurements (one destination)

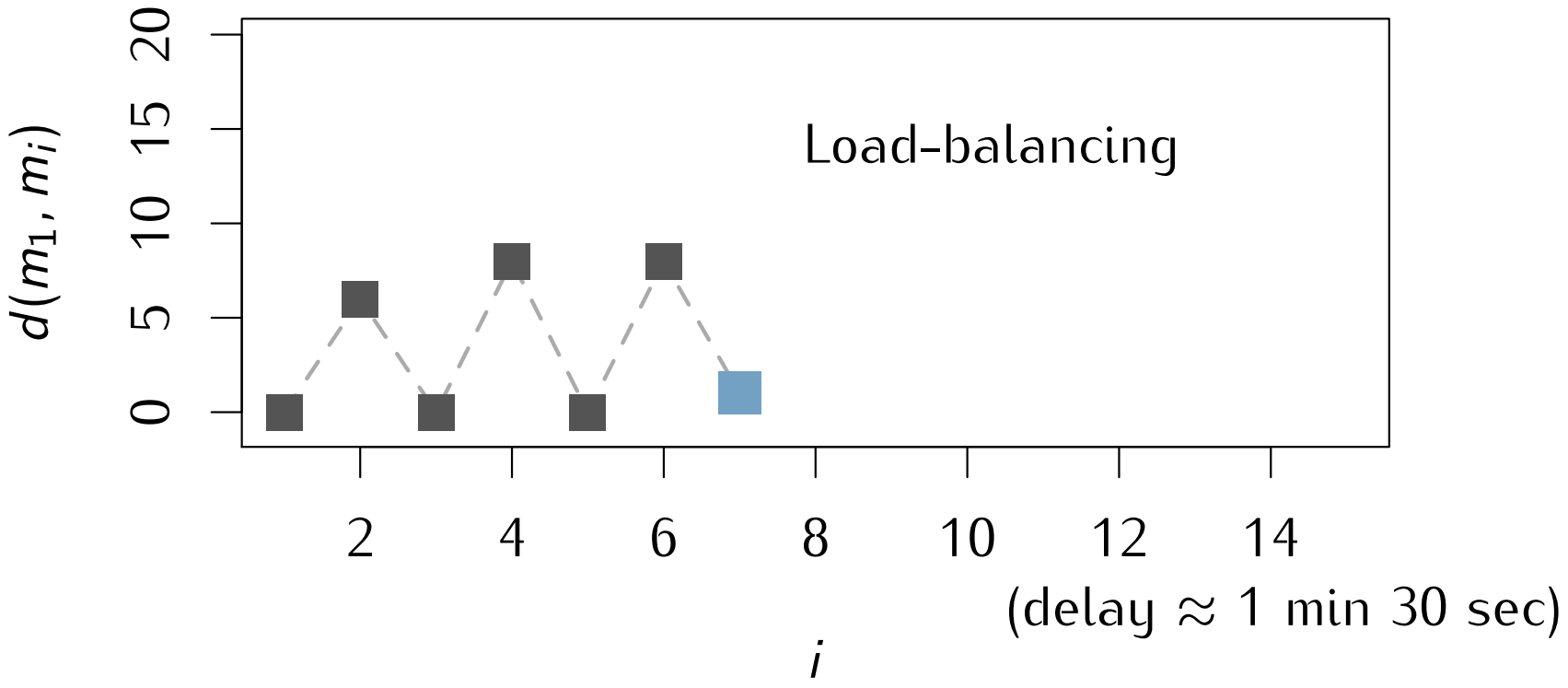
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





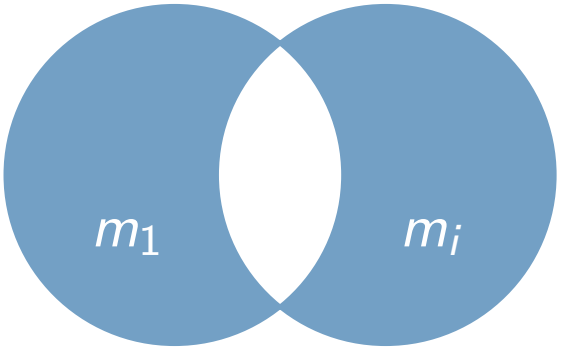
Evolution of symmetric difference between measurements (one destination)

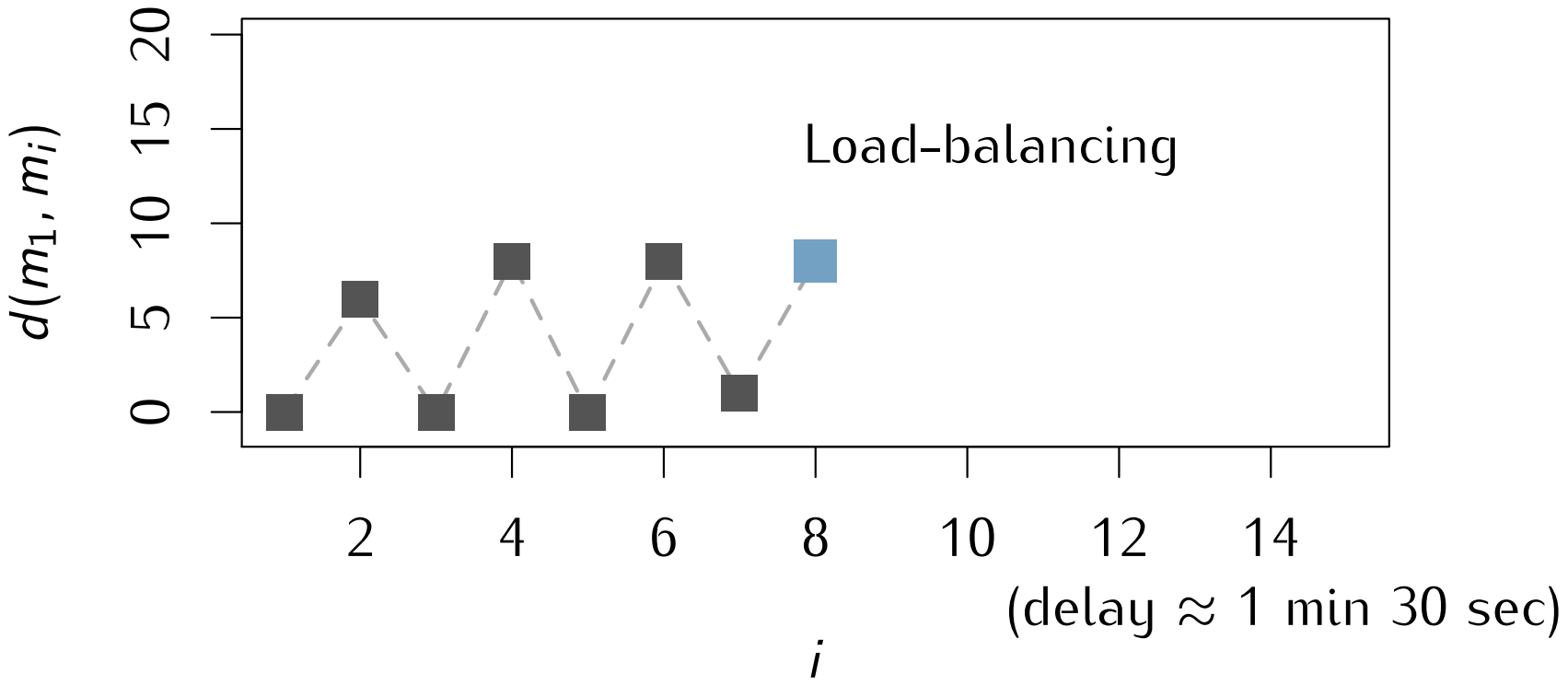
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





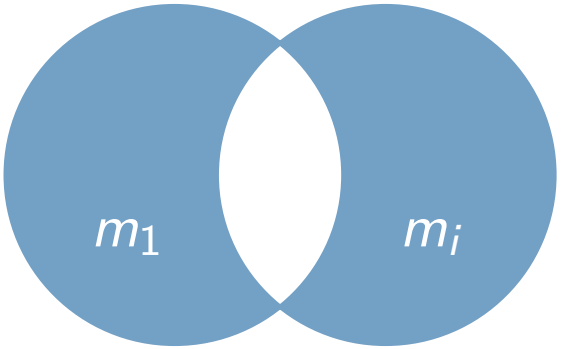
Evolution of symmetric difference between measurements (one destination)

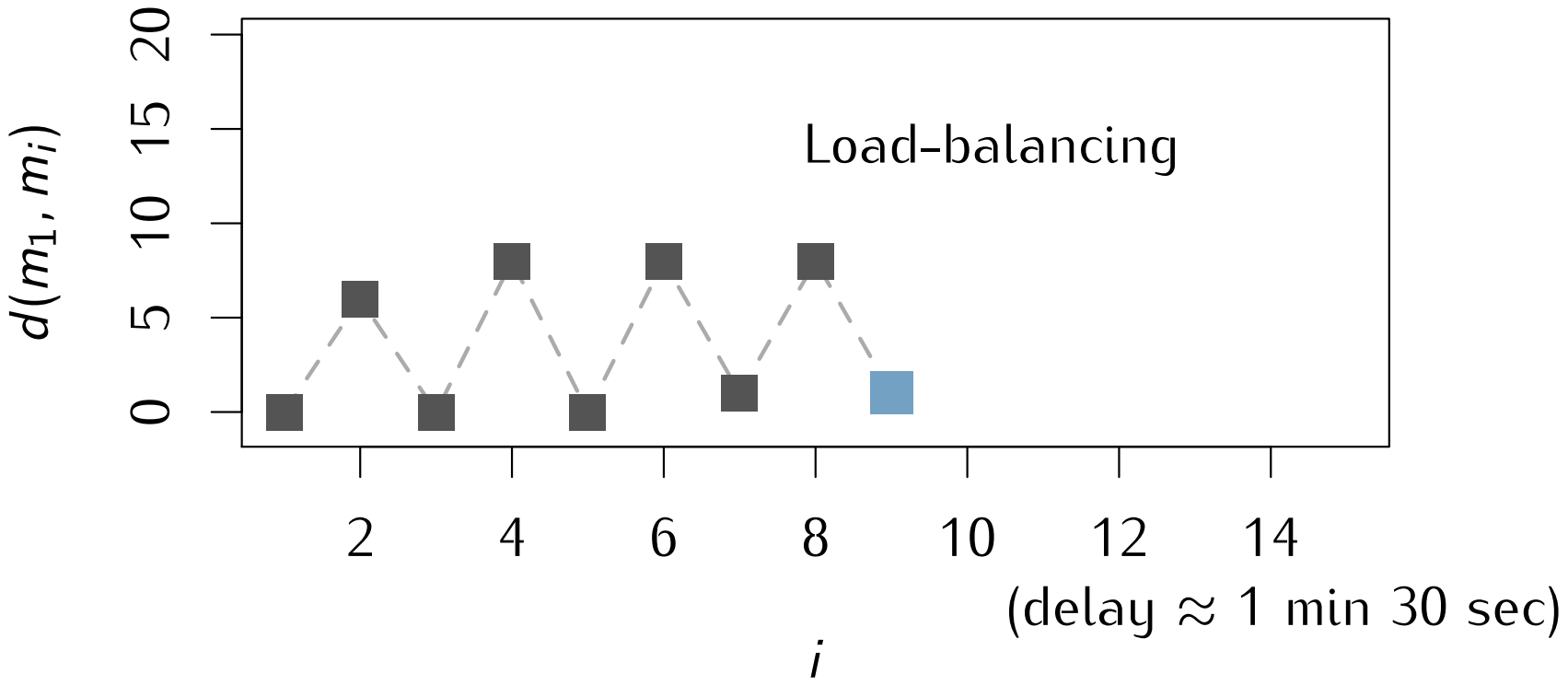
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





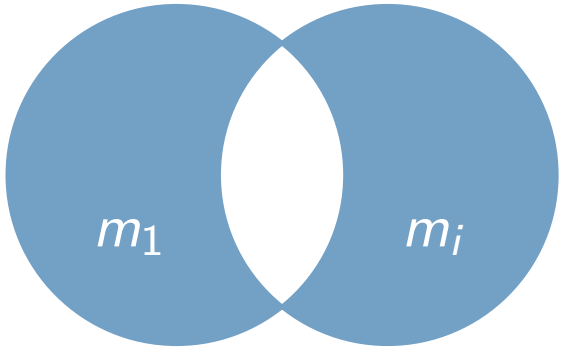
Evolution of symmetric difference between measurements (one destination)

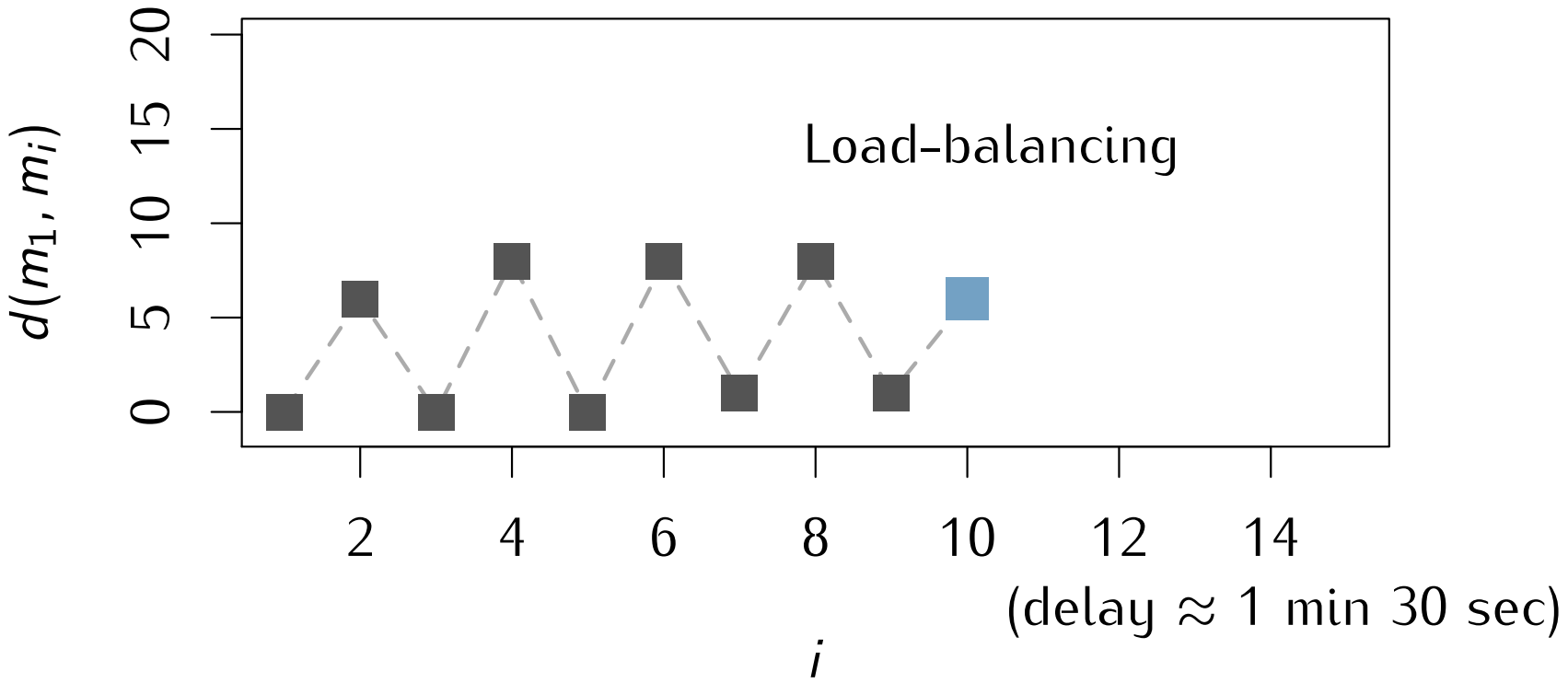
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





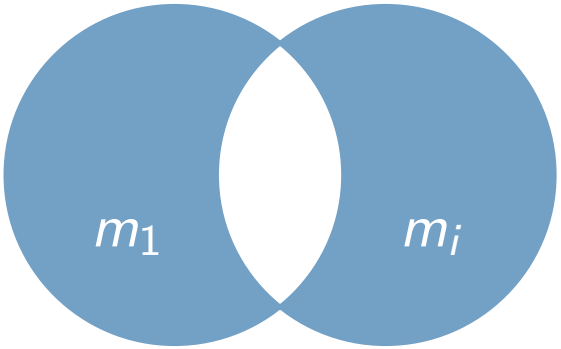
Evolution of symmetric difference between measurements (one destination)

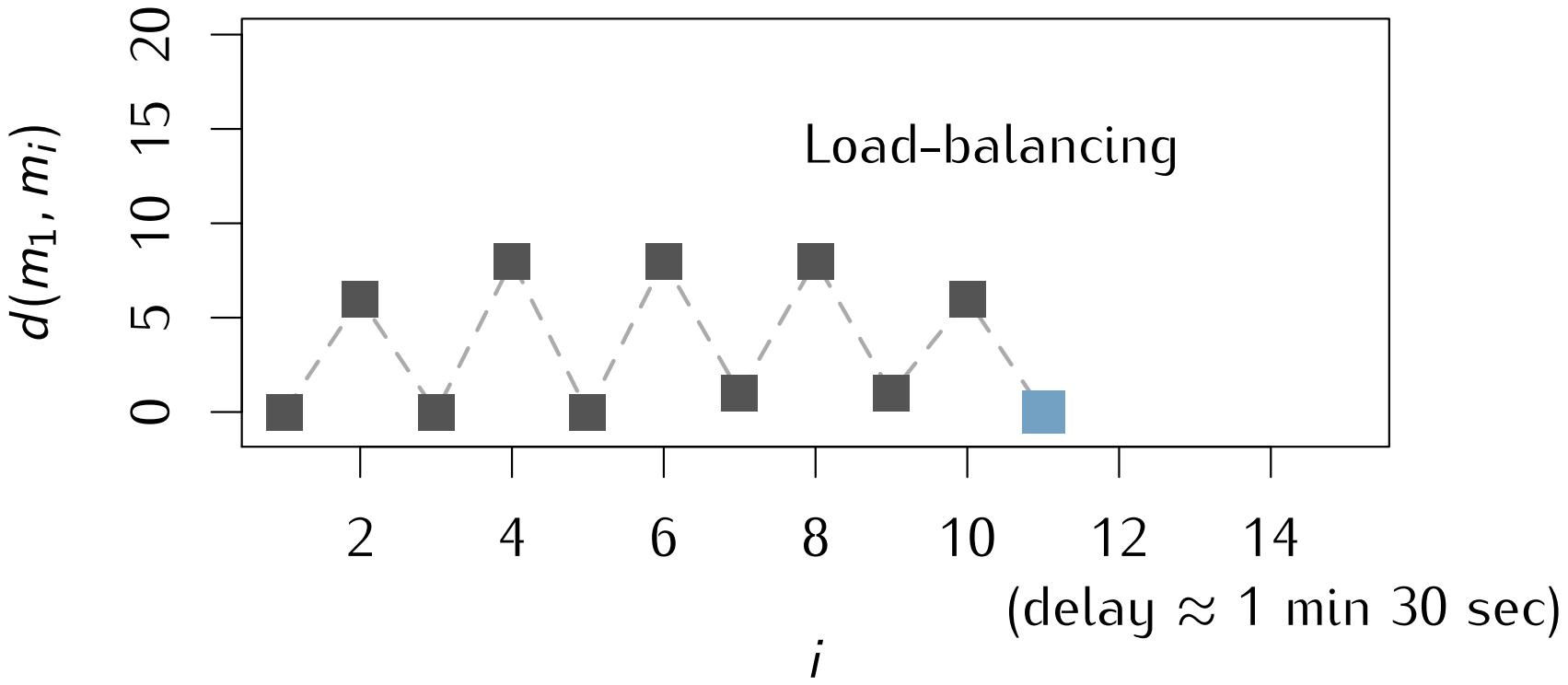
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





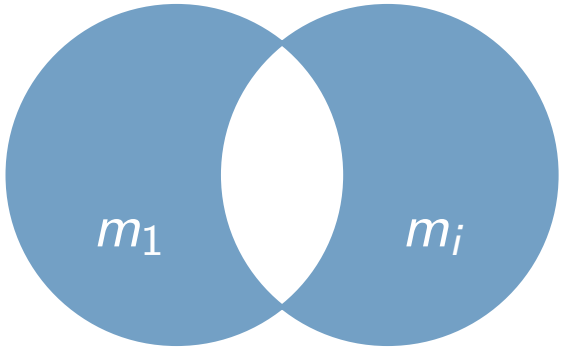
Evolution of symmetric difference between measurements (one destination)

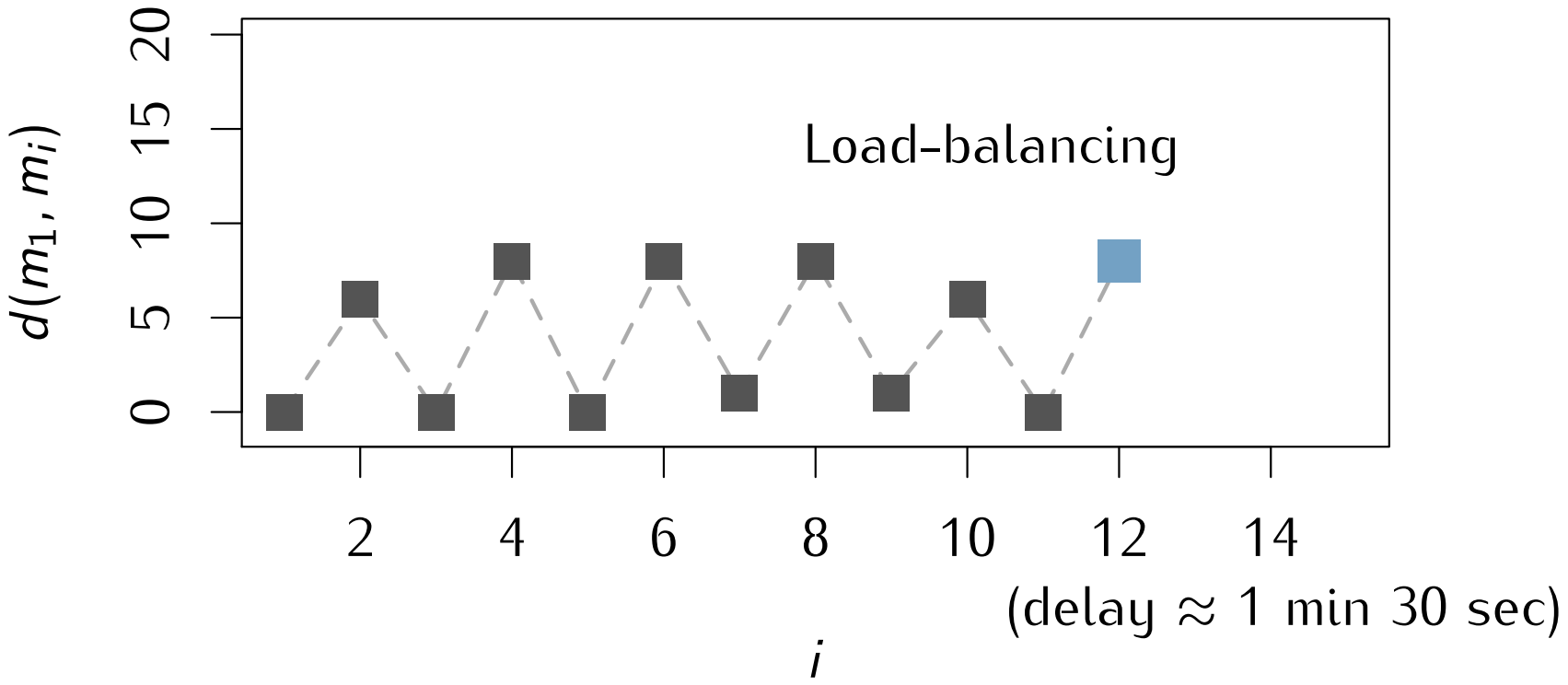
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





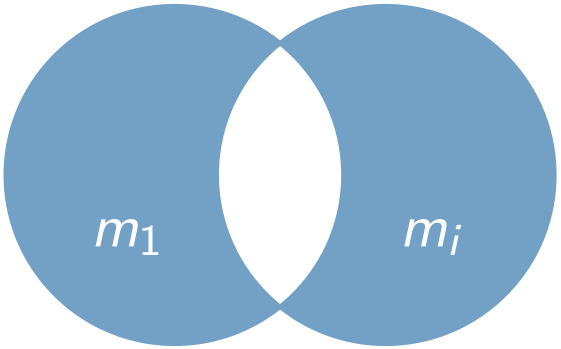
Evolution of symmetric difference between measurements (one destination)

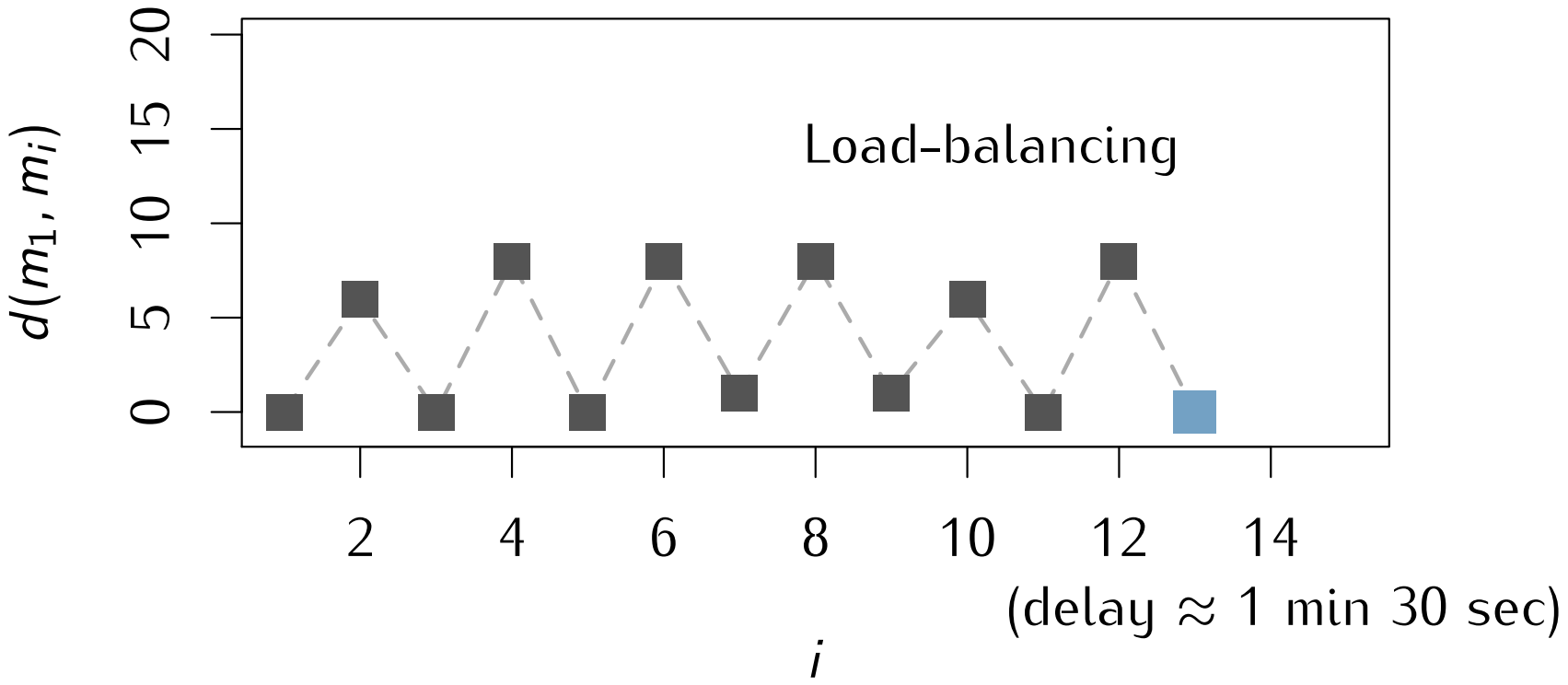
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





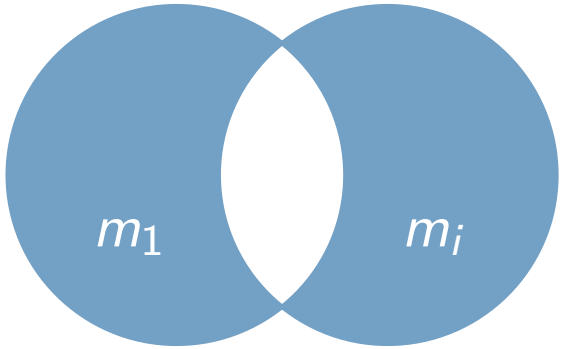
Evolution of symmetric difference between measurements (one destination)

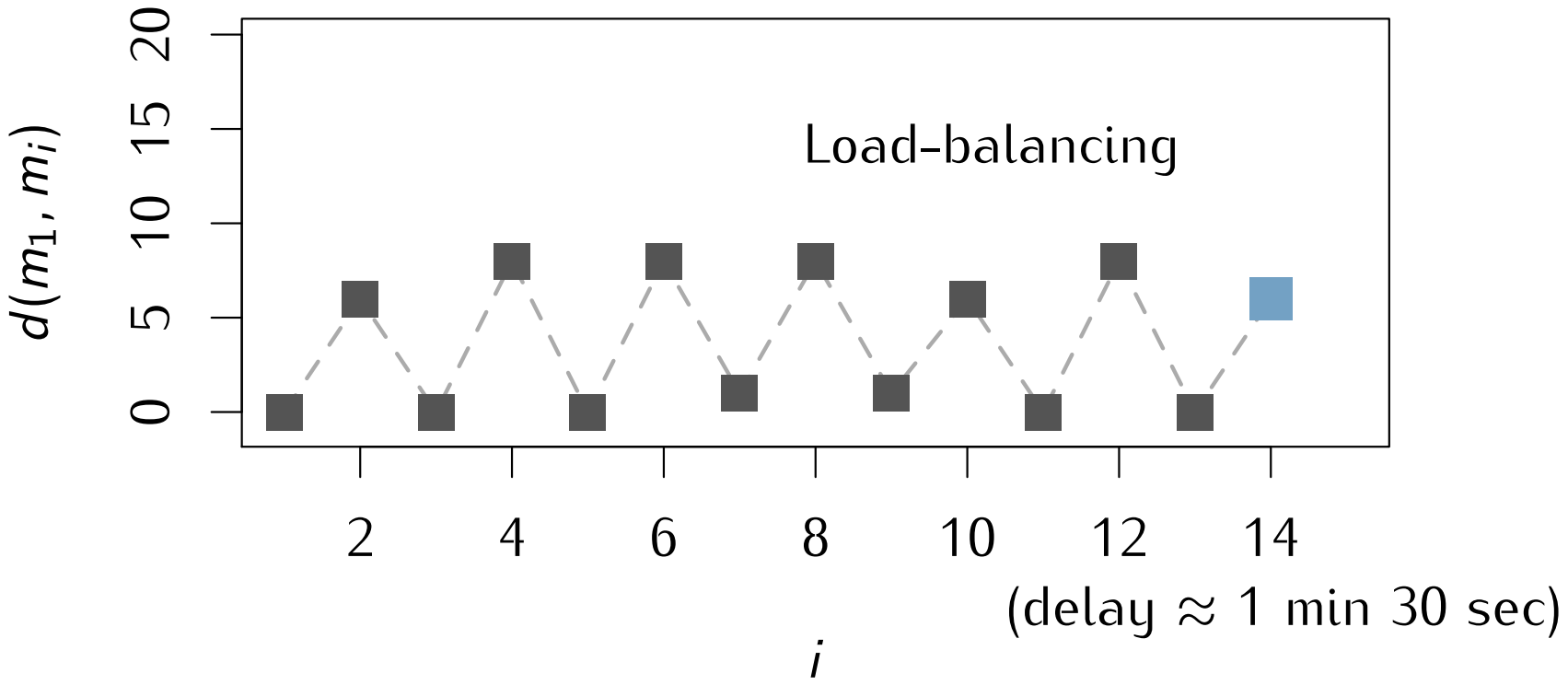
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





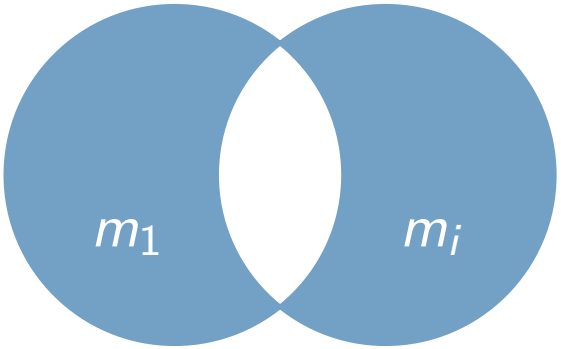
Evolution of symmetric difference between measurements (one destination)

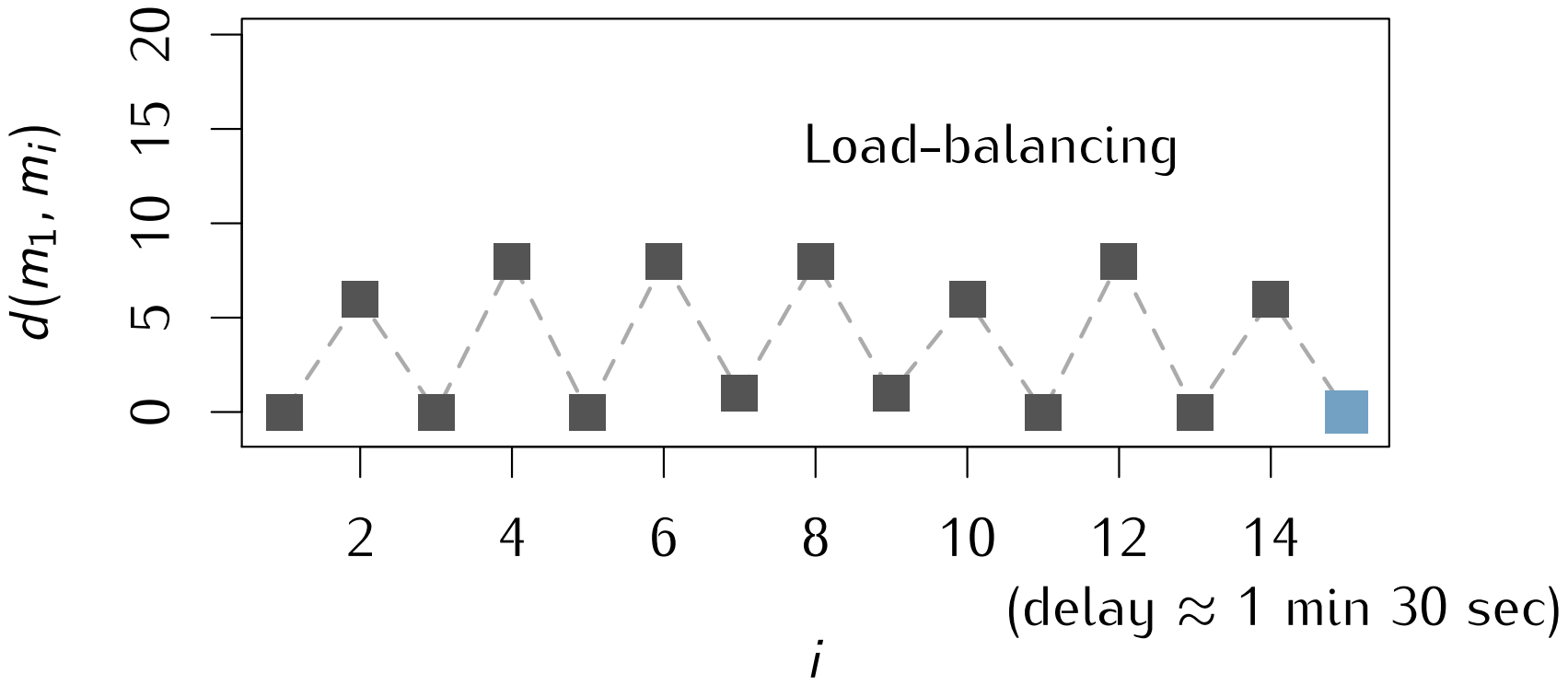
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





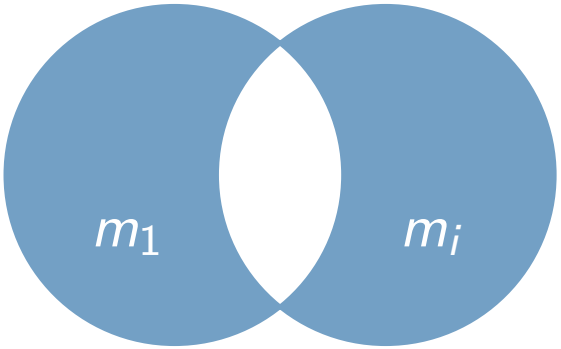
Evolution of symmetric difference between measurements (one destination)

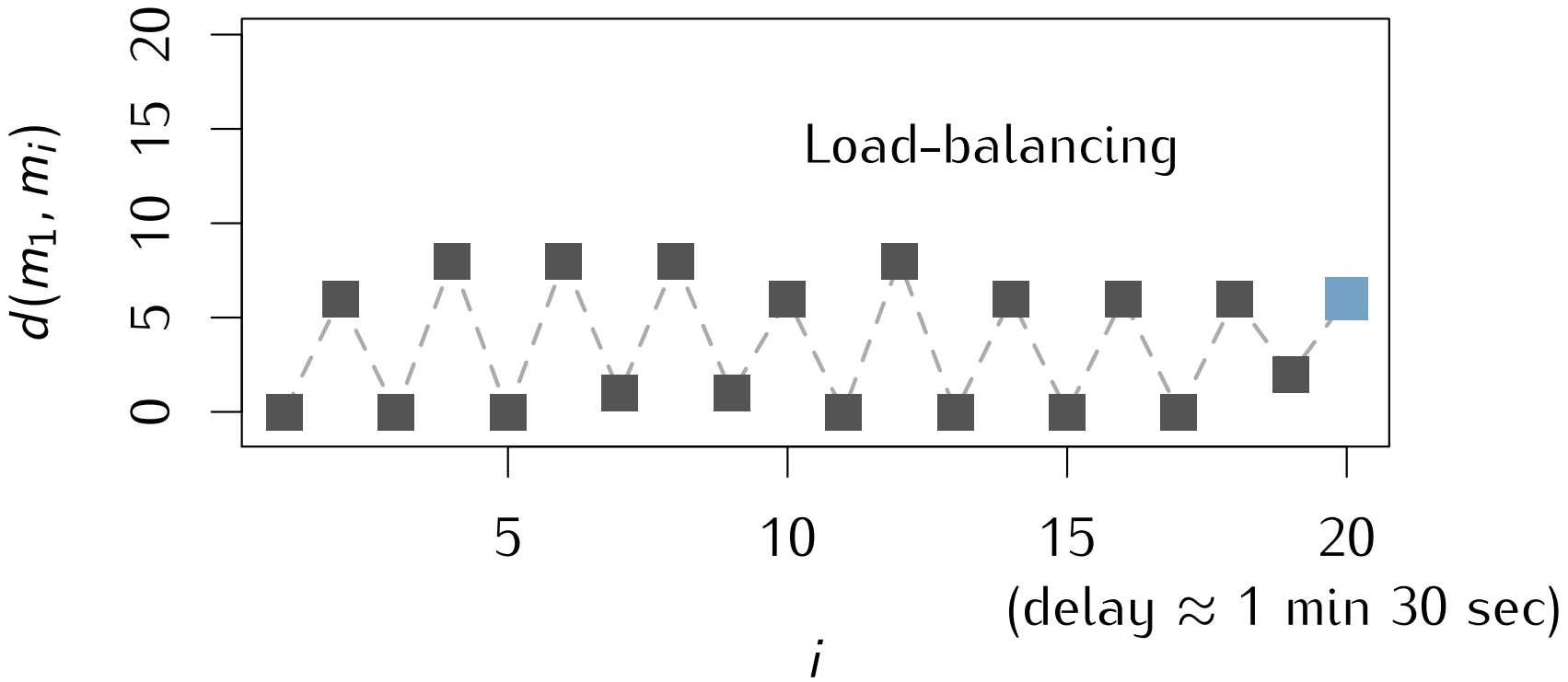
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





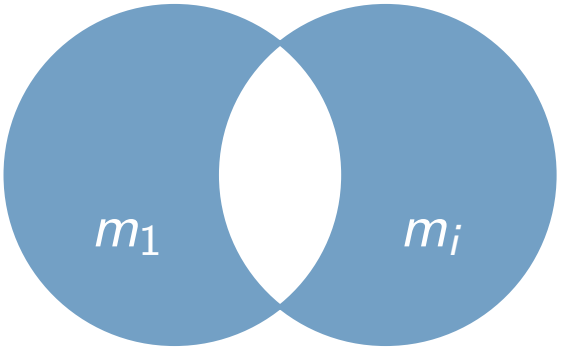
Evolution of symmetric difference between measurements (one destination)

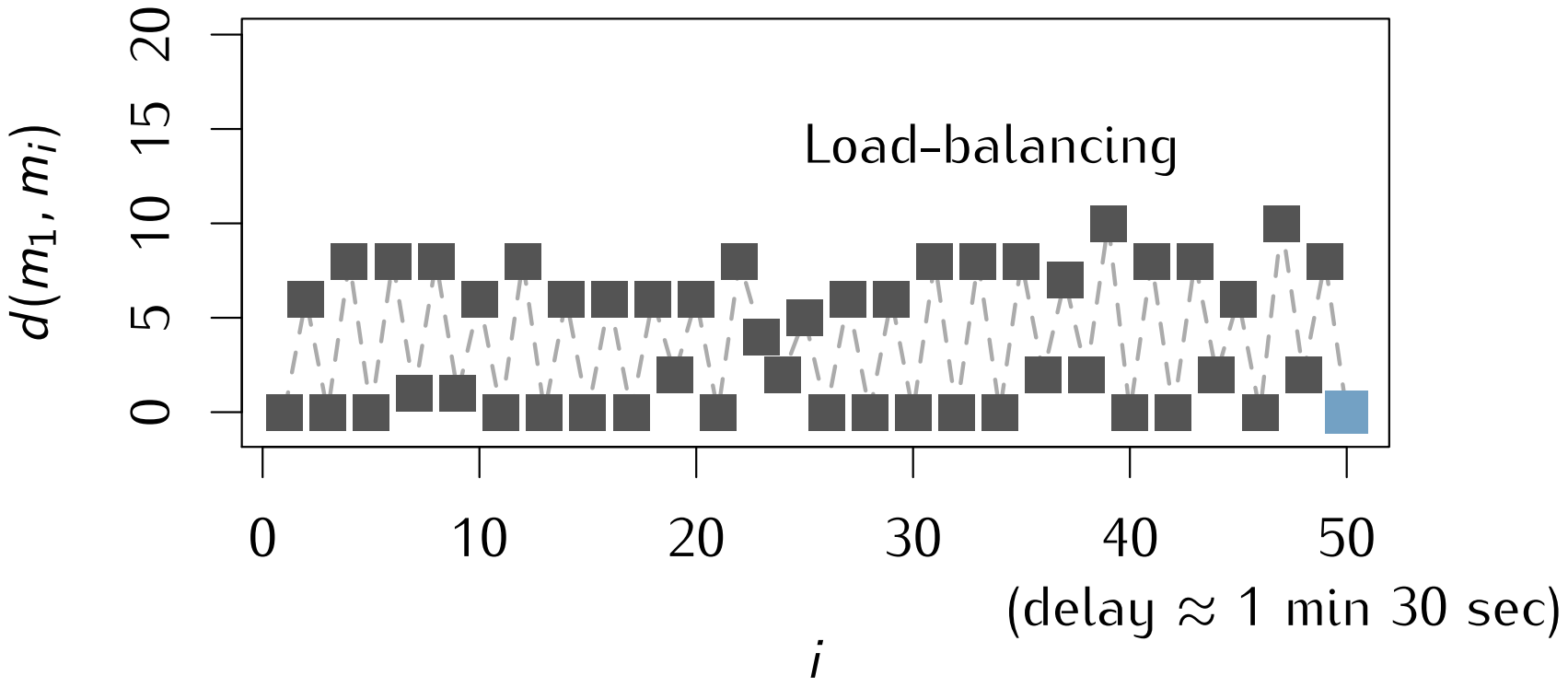
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





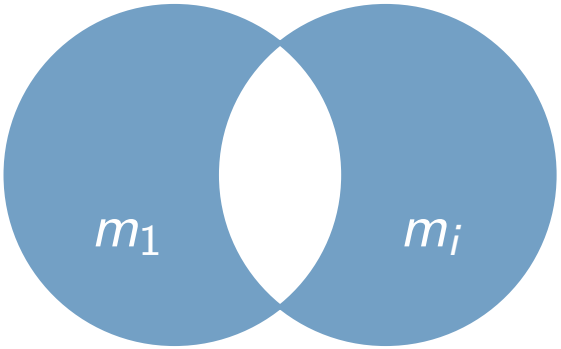
Evolution of symmetric difference between measurements (one destination)

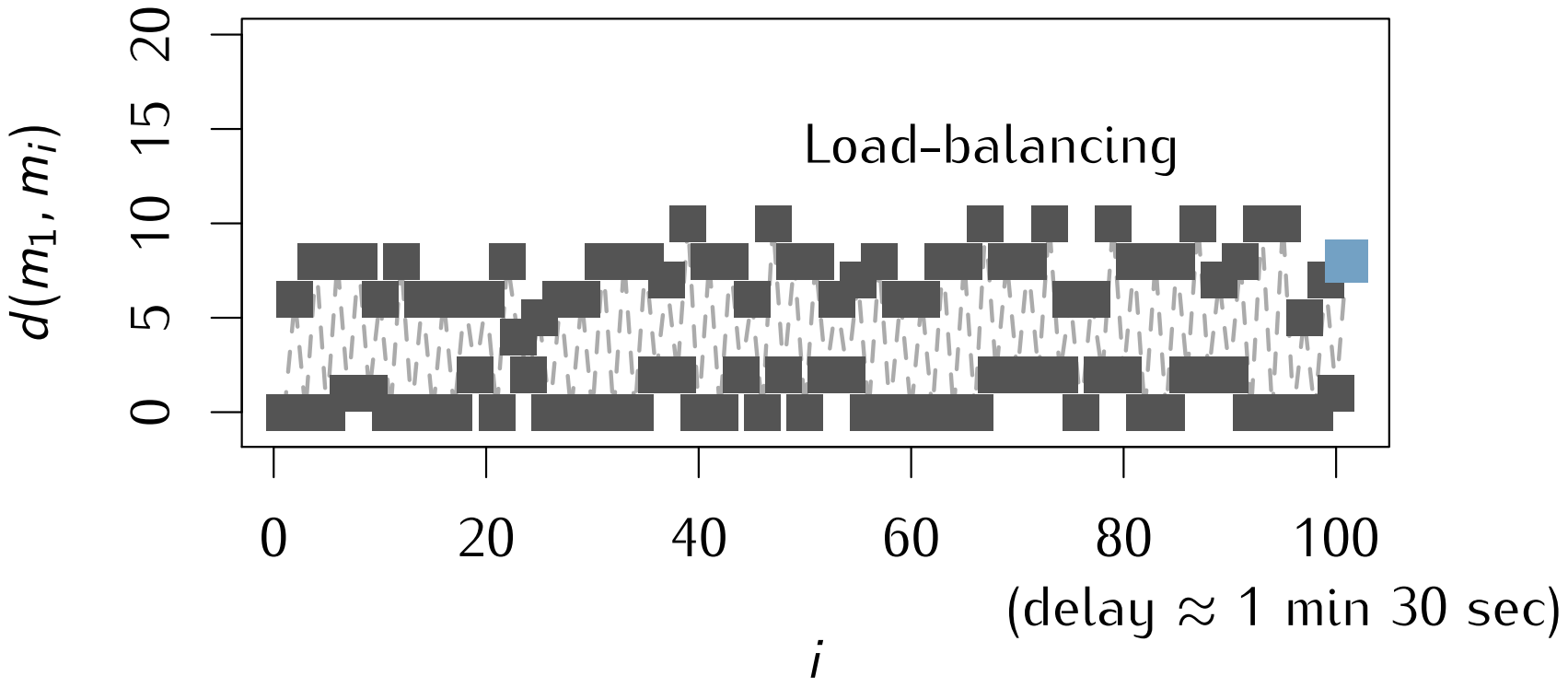
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





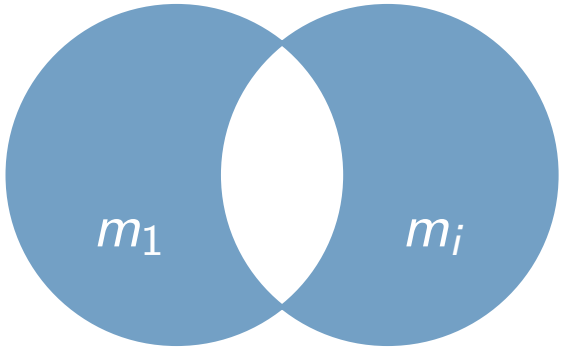
Evolution of symmetric difference between measurements (one destination)

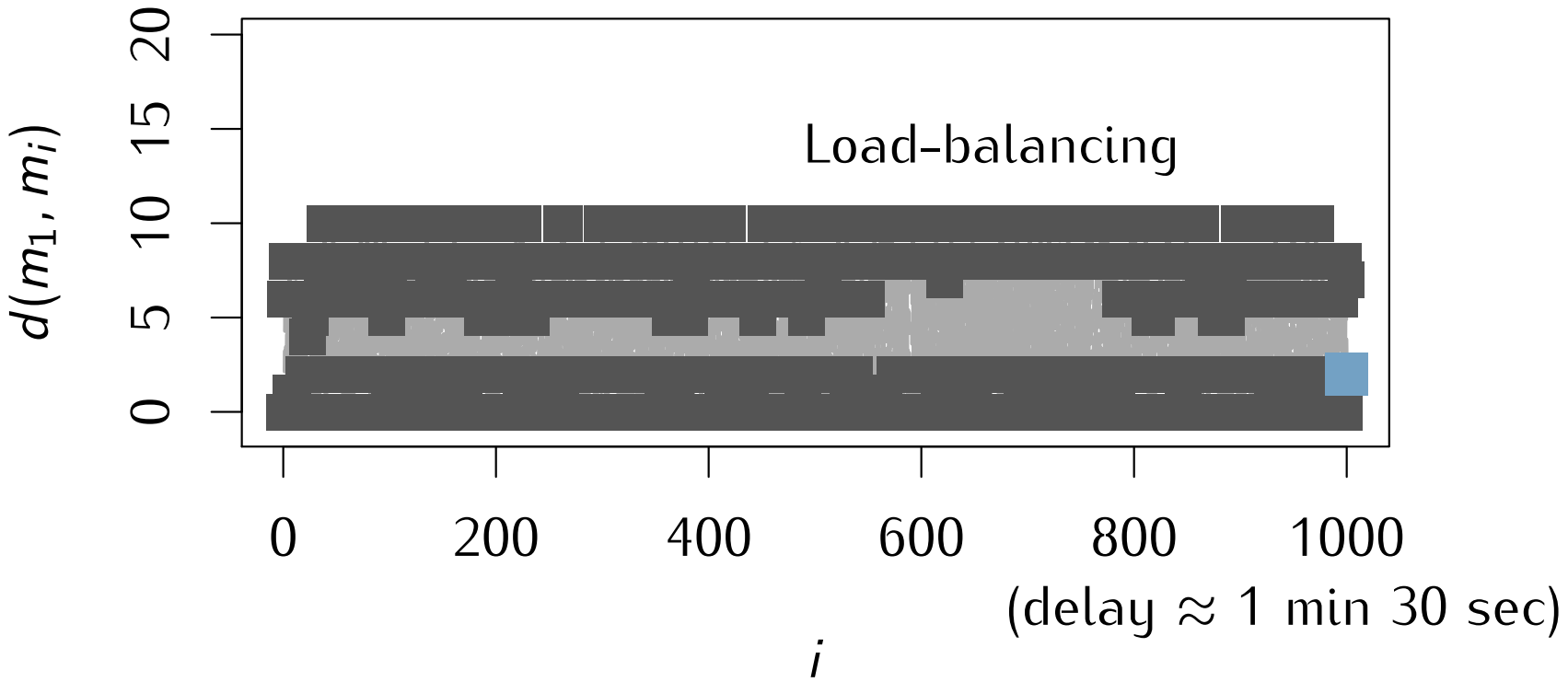
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





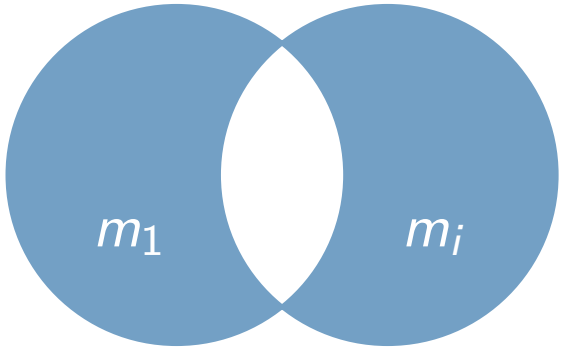
Evolution of symmetric difference between measurements (one destination)

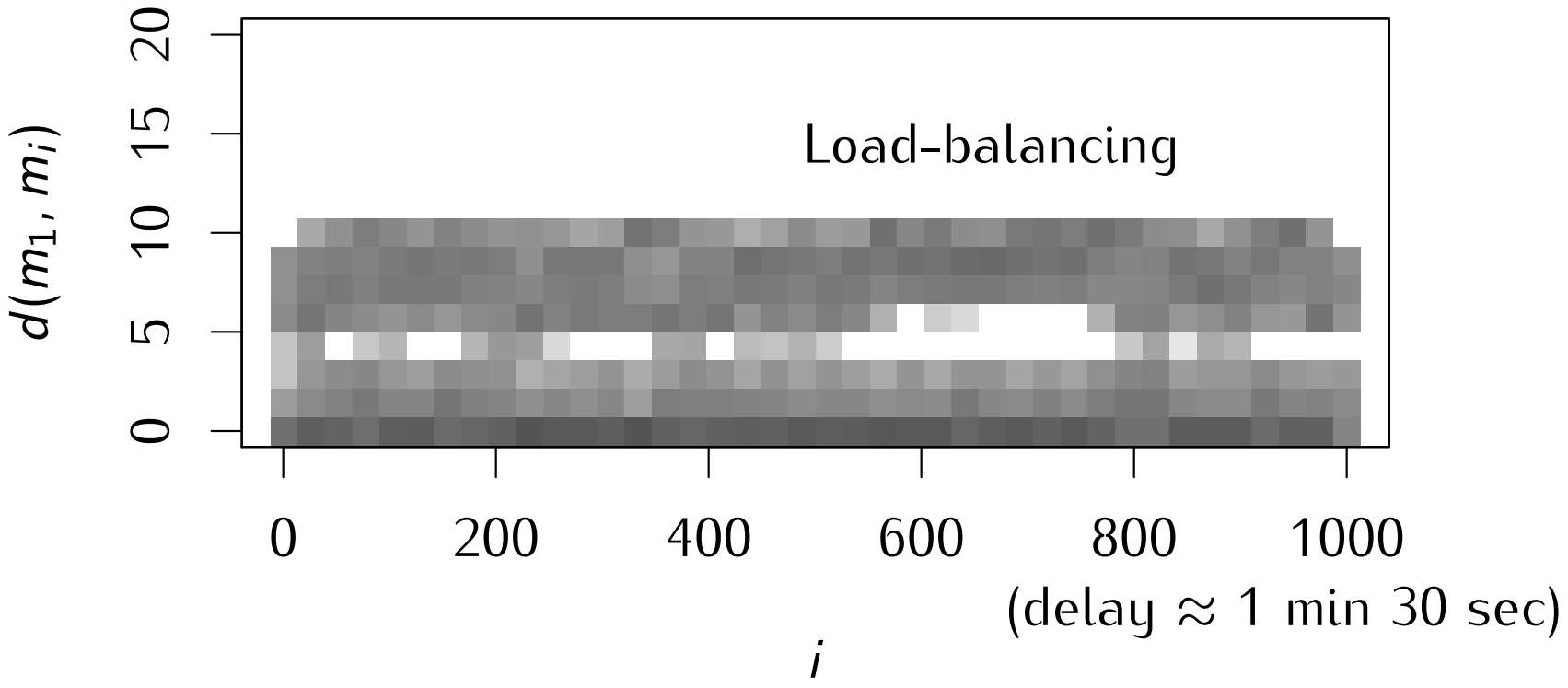
Measurement is a set of IP-links

m_1 : first measurement

m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$





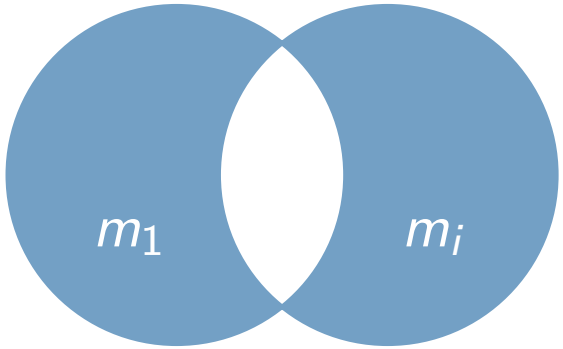
Evolution of symmetric difference between measurements (one destination)

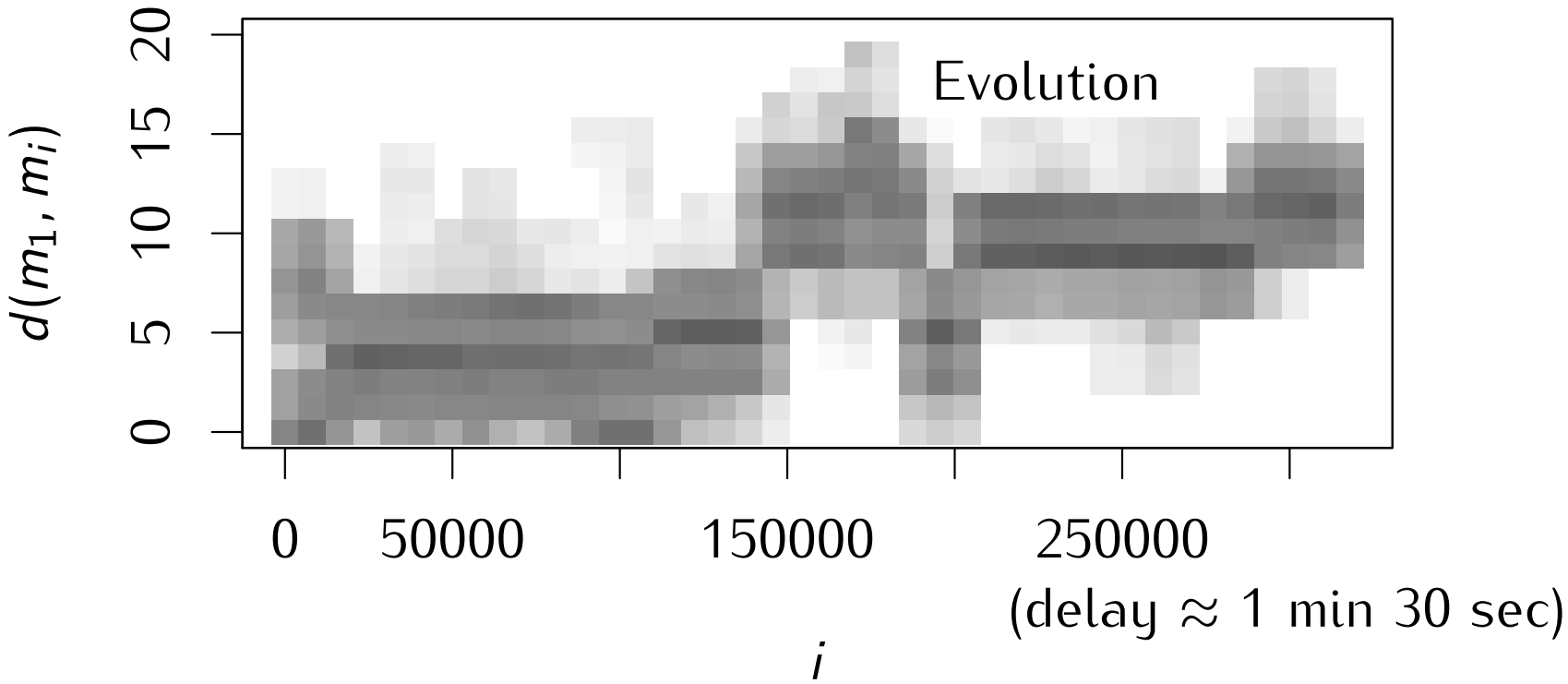
Measurement is a set of IP-links

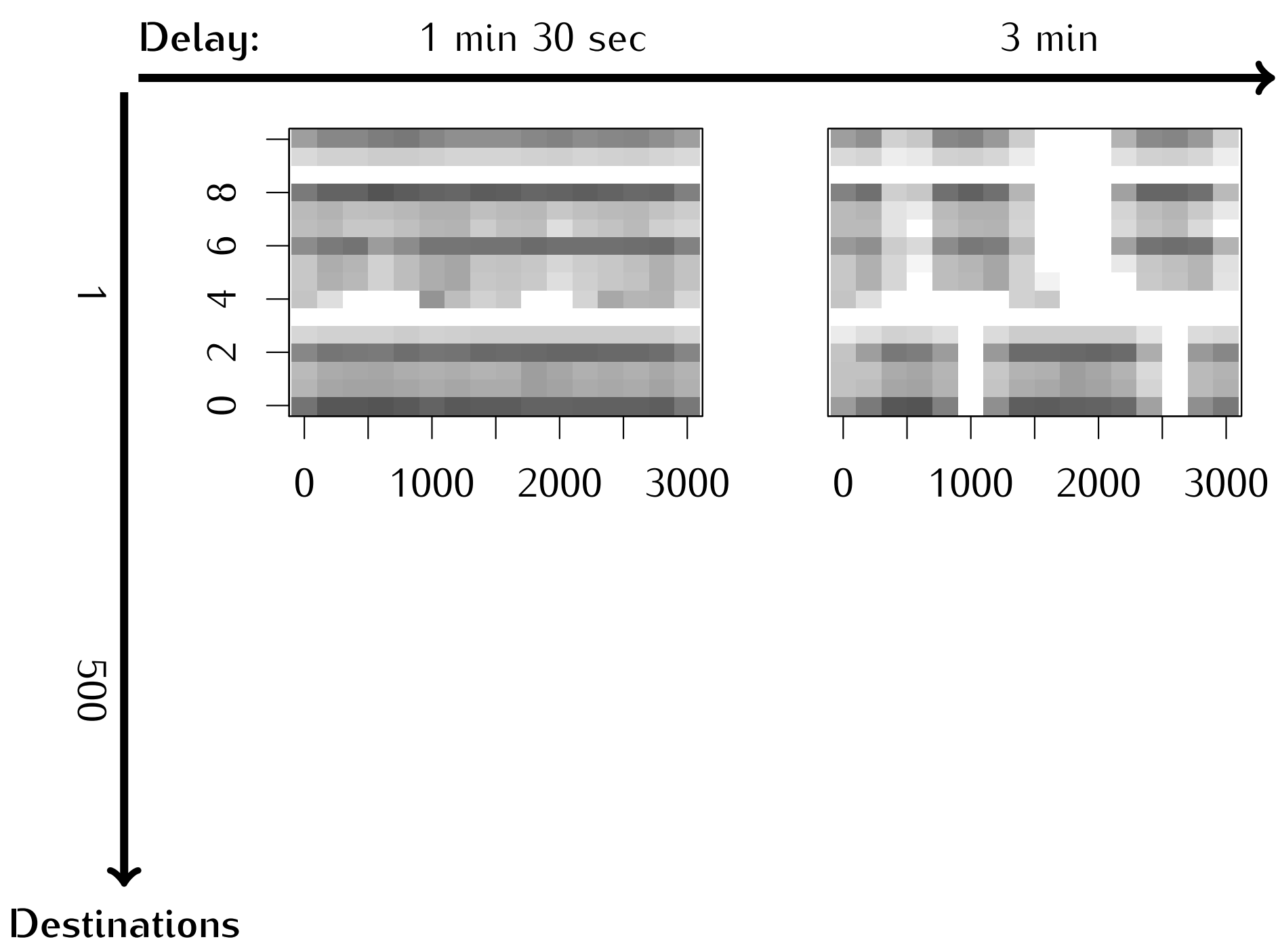
m_1 : first measurement

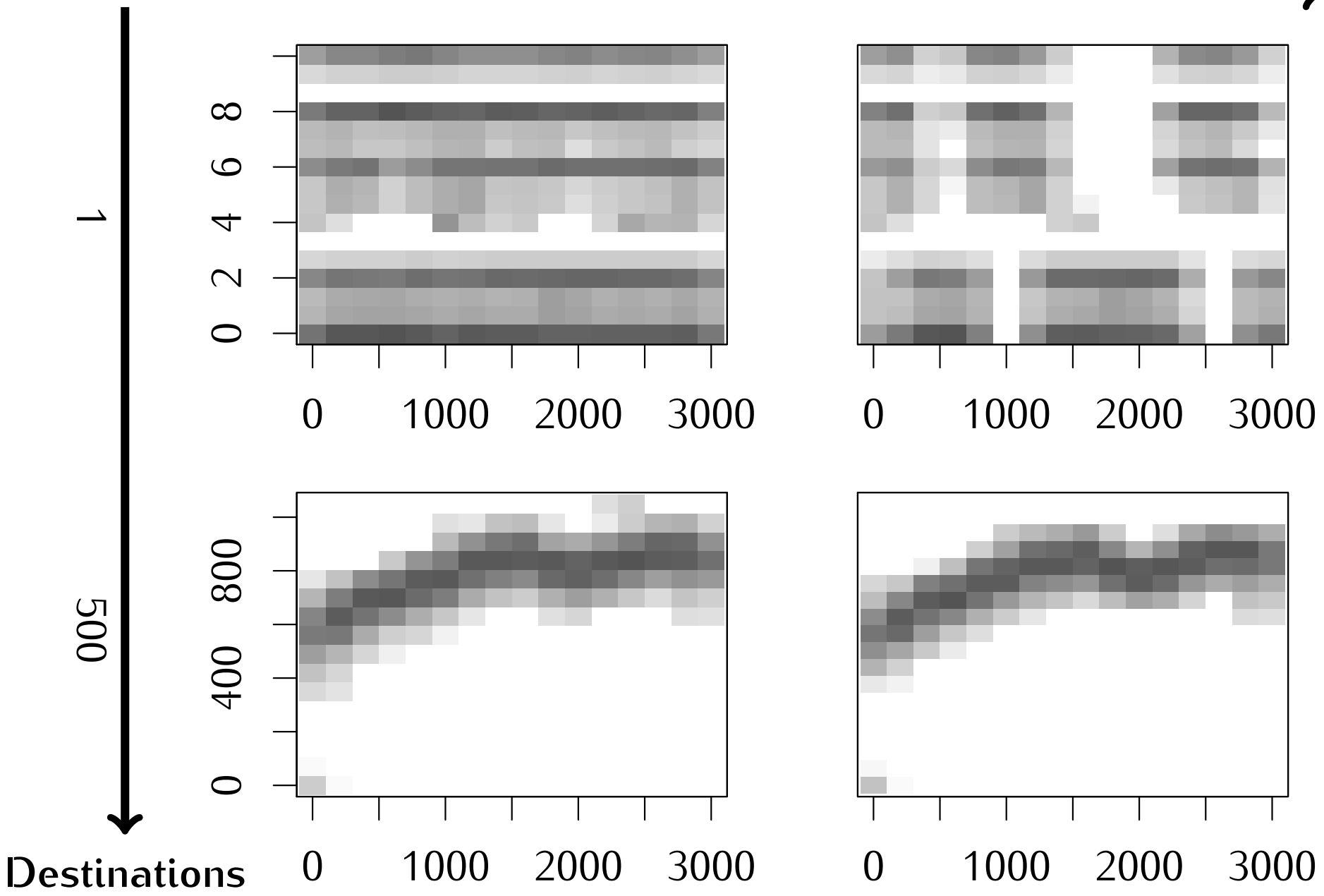
m_i : i-th measurement

$$d(m_1, m_i) = |\overline{m_1 \cap m_i}|$$

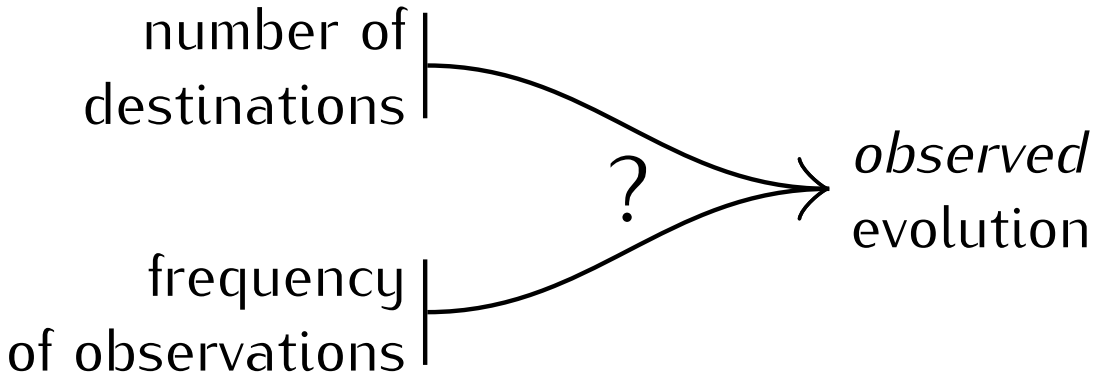





Delay:
1 min 30 sec
3 min
1
500
Destinations
0 2 4 6 8
0
1000
2000
3000
0
1000
2000
3000


Delay:
1 min 30 sec
3 min
1
500
Destinations
0 2 4 6 8
0 400 800
0
1000
2000
3000

Overview of problems and methods



Methods:

- Real-world measurements
- Simulated measurements using random graphs
- Theoretical study of dynamic random graphs
- Stochastic process estimation from partial observations

Questions?

http://kirgizov.complexnetworks.fr/