Reducing the Subscription Latency in Reliable Causal Publish-Subscribe Systems

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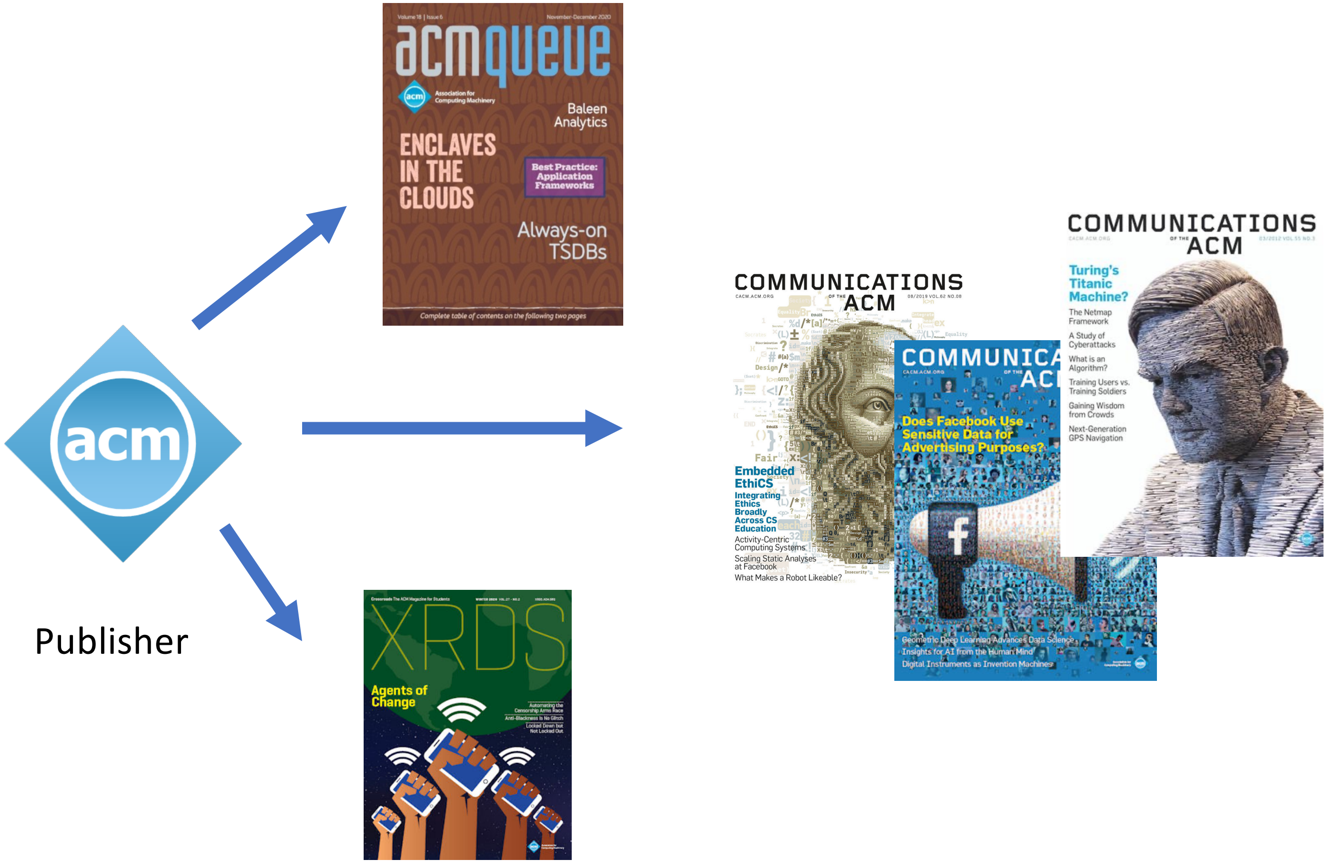
Publish-Subscribe



Publisher

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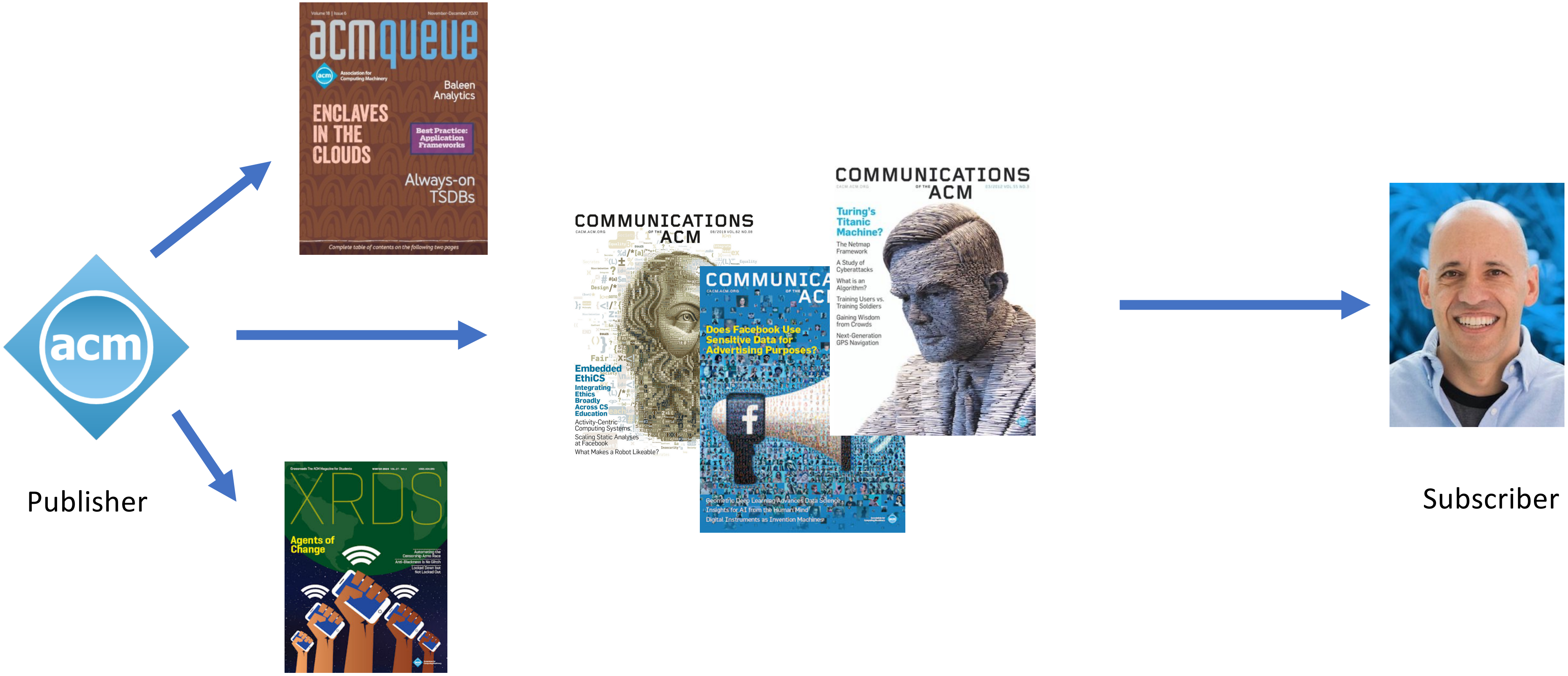
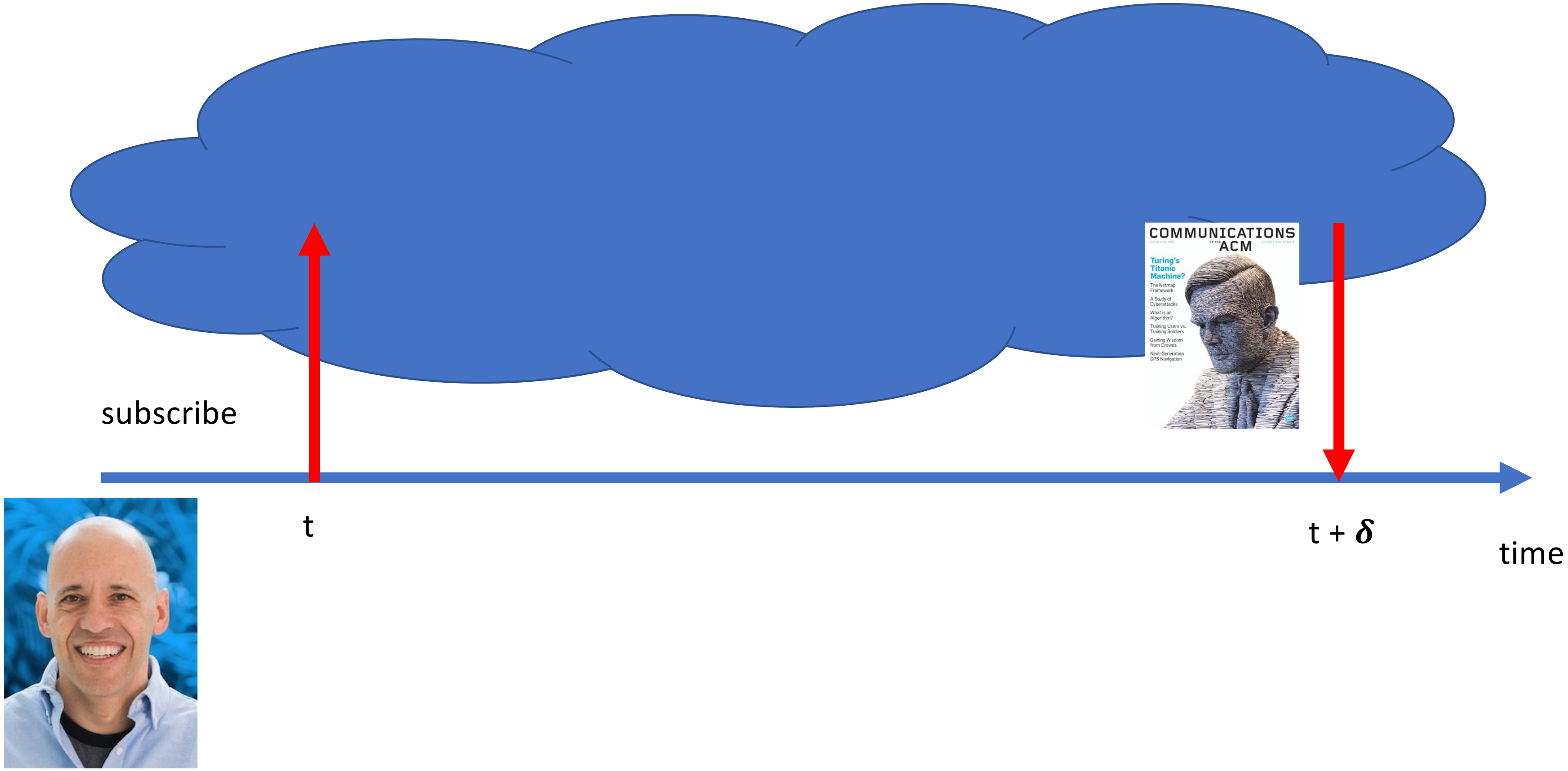
Publish-Subscribe



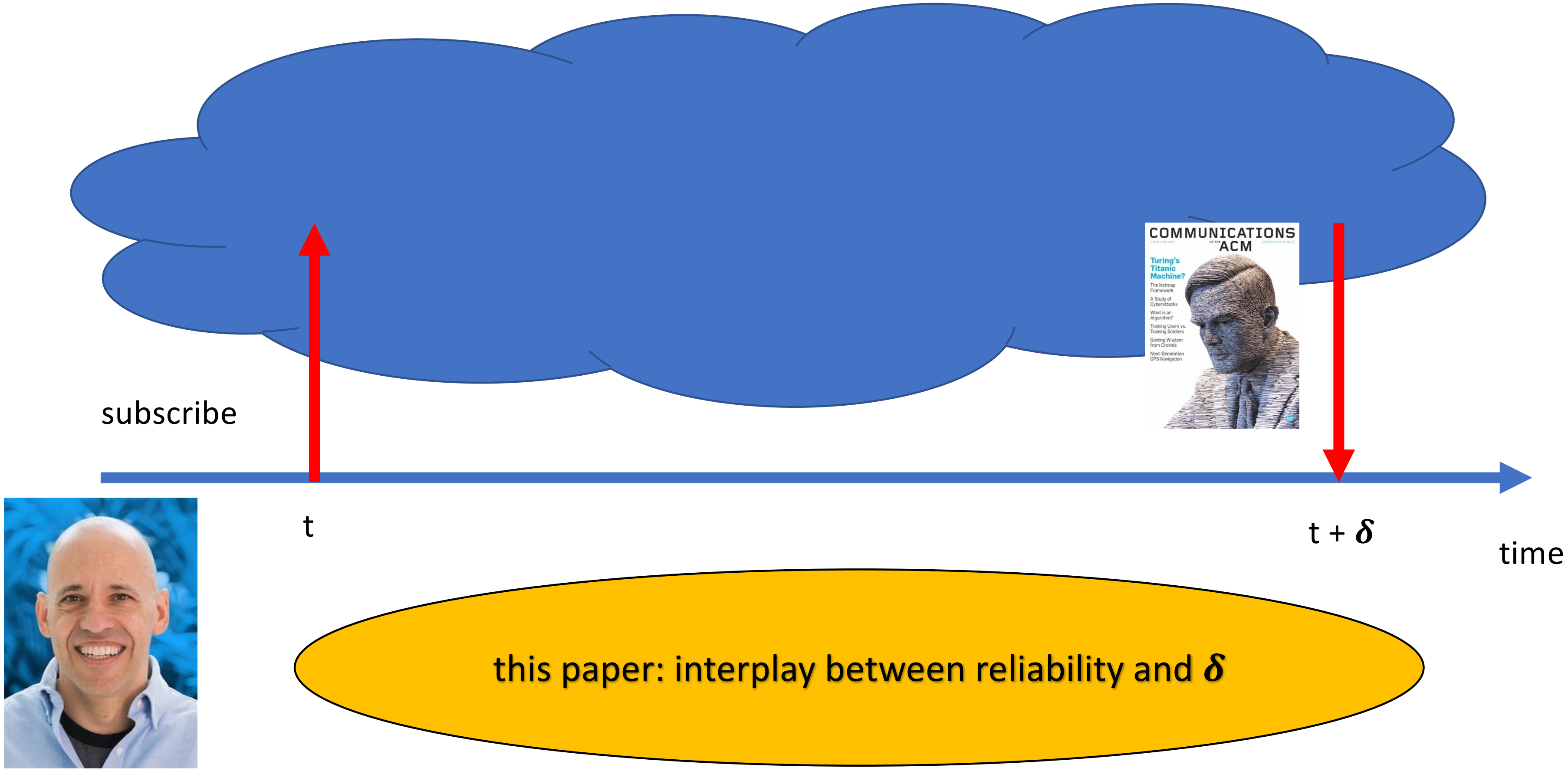
Publisher

Subscriber

Subscription Latency



Subscription Latency

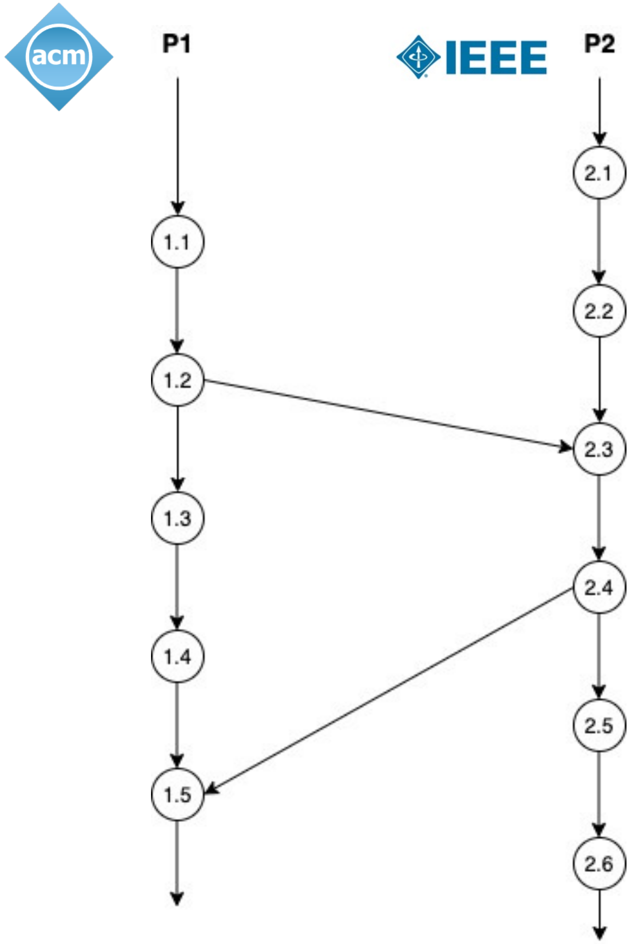

COMMUNICATIONS OF THE ACM
Turing's Titanic Machine?
subscribe
t
t + $\boldsymbol{\delta}$
time

this paper: interplay between reliability and $\boldsymbol{\delta}$

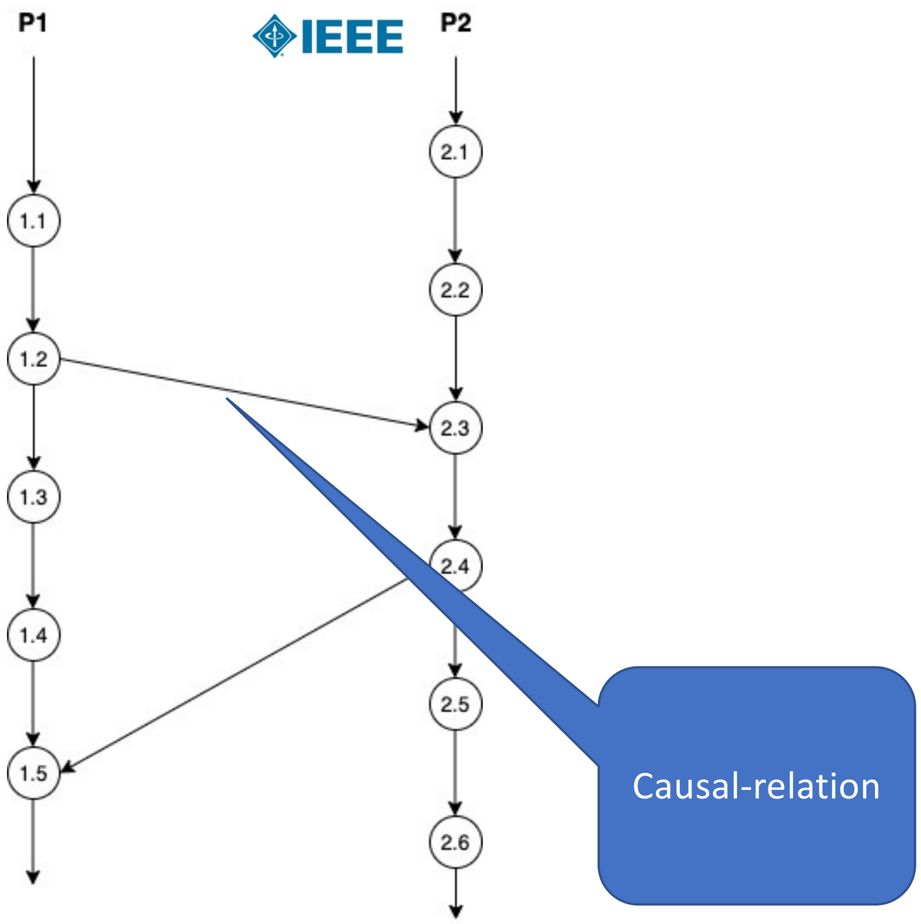
Reliability vs Subscription Latency

- **Best-Effort Delivery**
    - Subscriber can miss some events
- **Gapless FIFO Delivery (GFD)**
    - After receiving some event **e** from publisher **p**, the subscriber receives all future events <u>from that</u> publisher **p**
- **Gapless Causal Delivery (GCD)**
    - After receiving some event **e** from publisher **p**, the subscriber receives all future events, that causally depend on **e**, <u>from any</u> publisher (and not only from **p**).

Gapless FIFO vs Gapless Causal Delivery

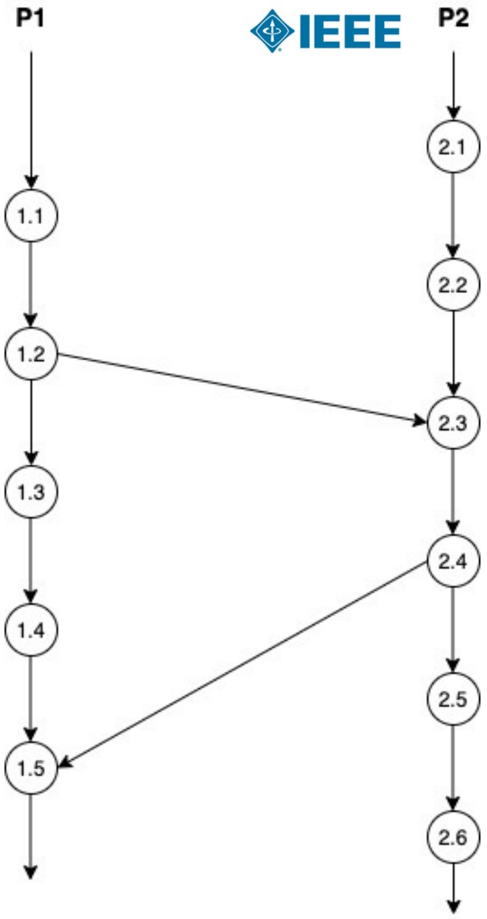


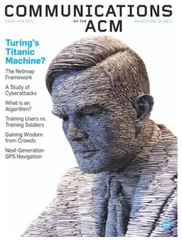
Gapless FIFO vs Gapless Causal Delivery



Causal-relation

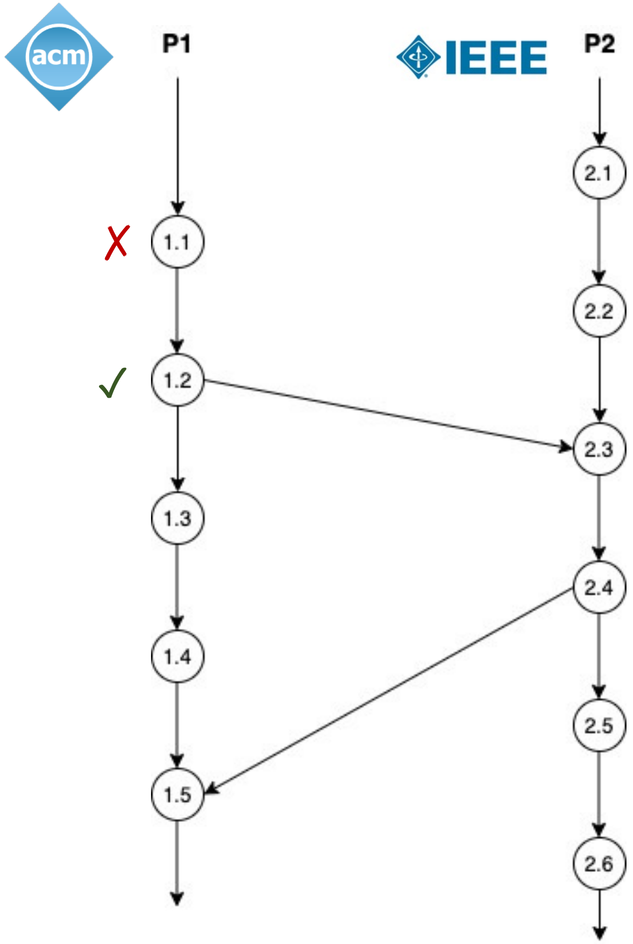
Gapless FIFO vs Gapless Causal Delivery



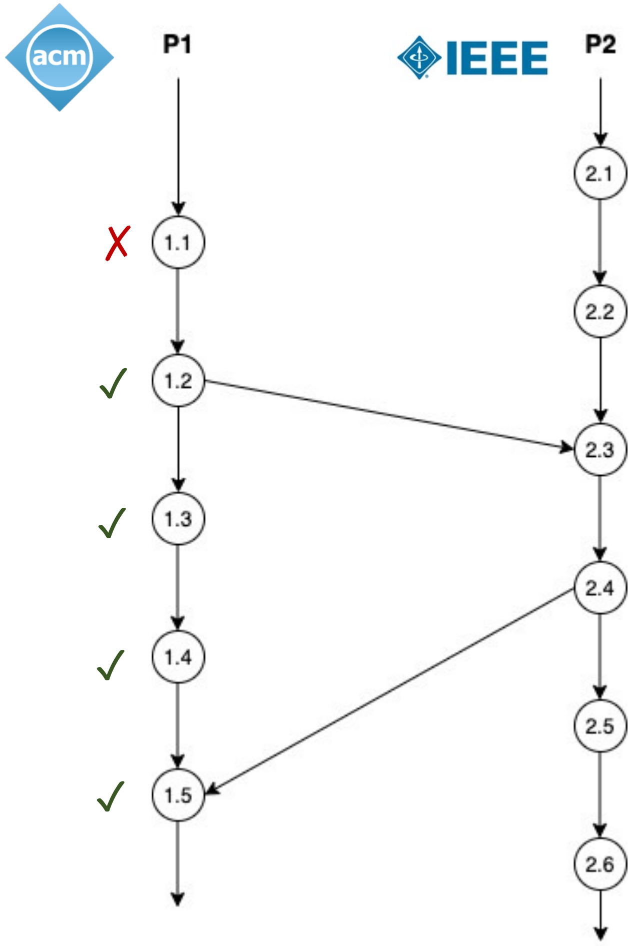


Paper in Computer cites a paper in Comm ACM

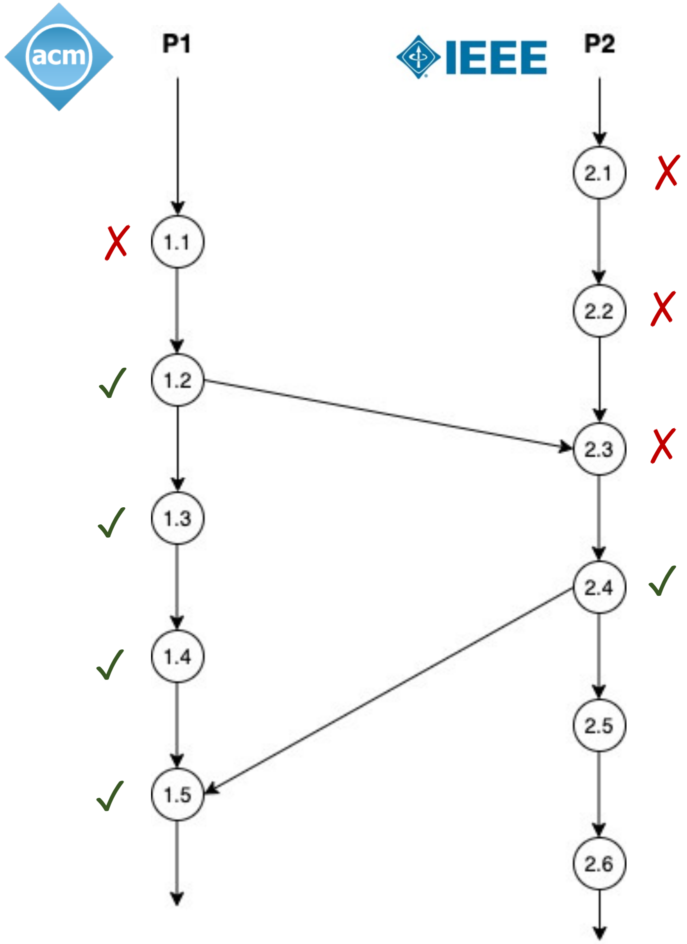
Gapless FIFO vs Gapless Causal Delivery



Gapless FIFO vs Gapless Causal Delivery



Gapless FIFO vs Gapless Causal Delivery



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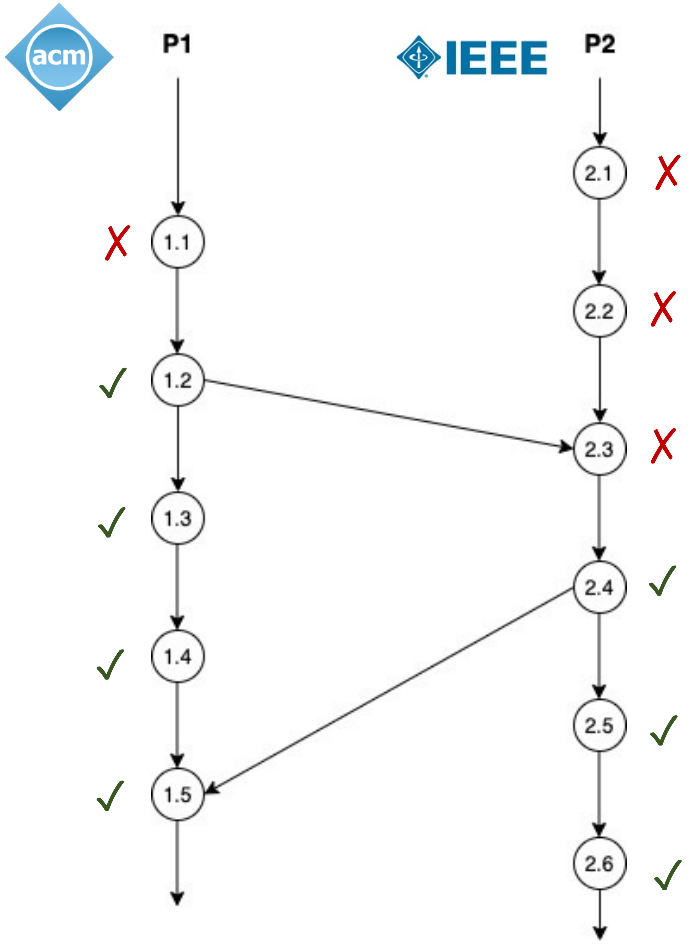

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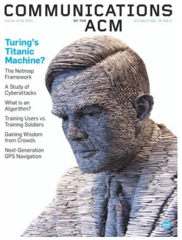
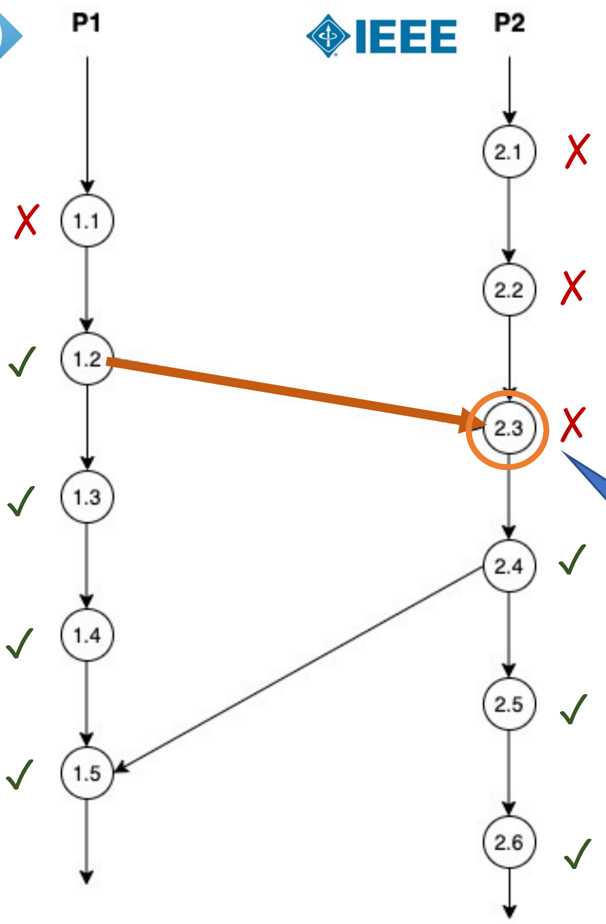




GAP in the causal history of the subscriber!

Reliability vs Subscription Latency

- FIFO is **stronger** than best-effort.
- FIFO brings **higher** subscription **latency** than best-effort.

Reliability vs Subscription Latency

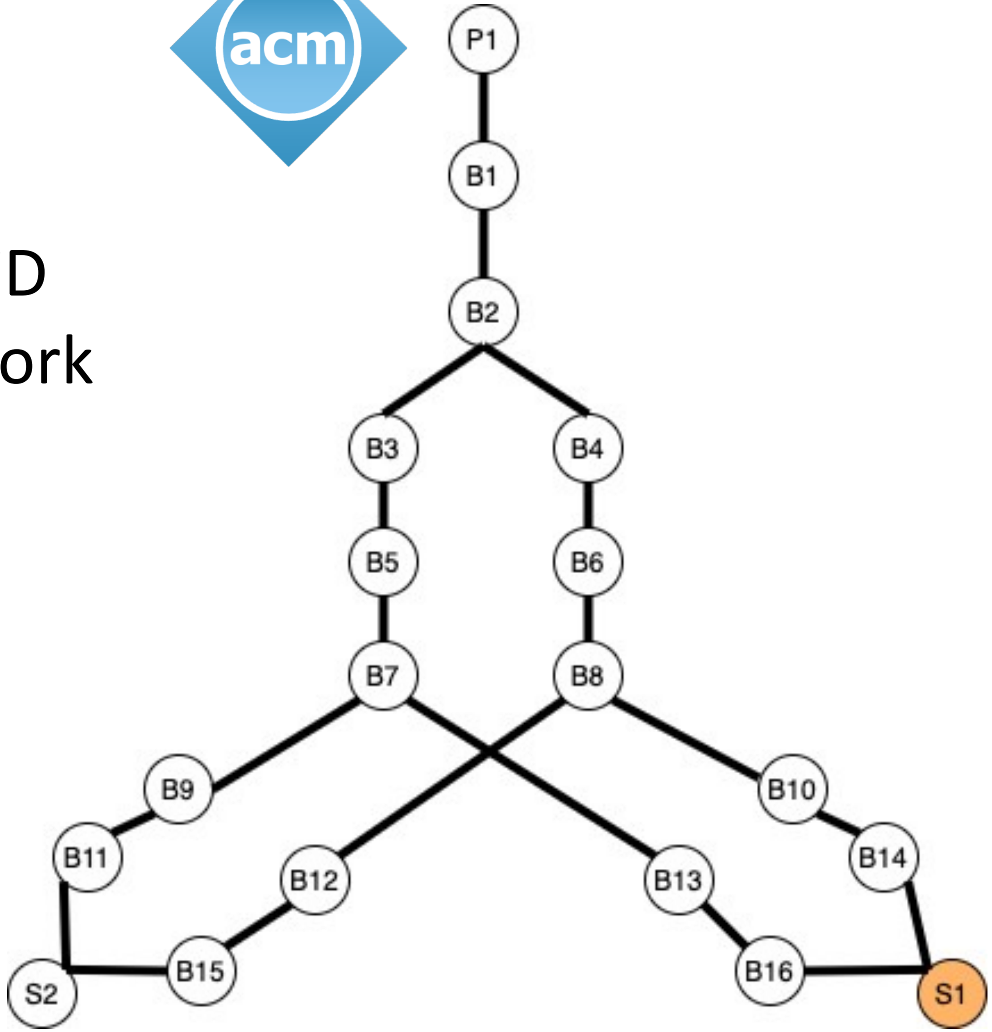
- CAUSAL is **stronger** than FIFO.
- Does CAUSAL bring even higher latency subscription than FIFO?

Reliability vs Subscription Latency

- CAUSAL is **stronger** than FIFO.
- Does CAUSAL bring even higher latency subscription than FIFO?

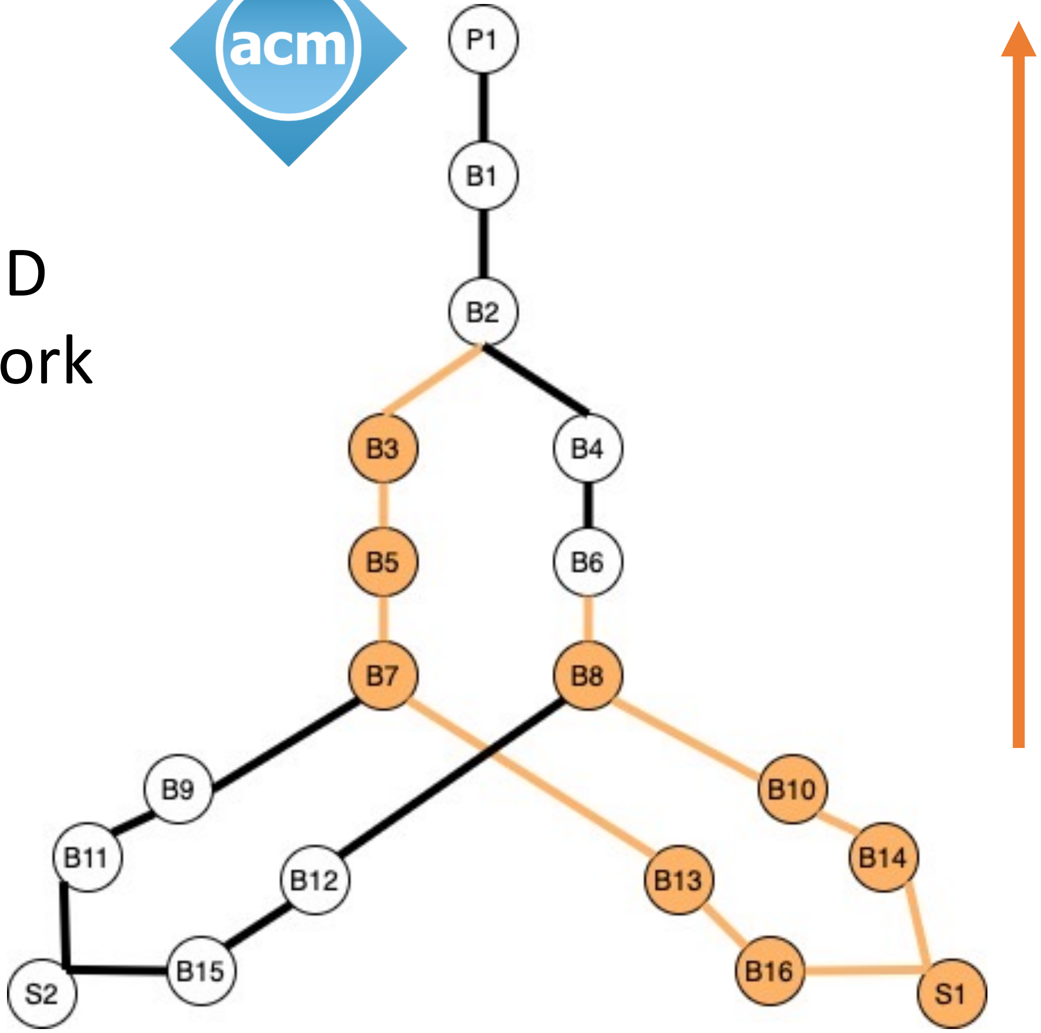
- To answer this question, we need to understand how we can enforce GFD and GCD in practice.

Implementing GFD on a broker network



Alan

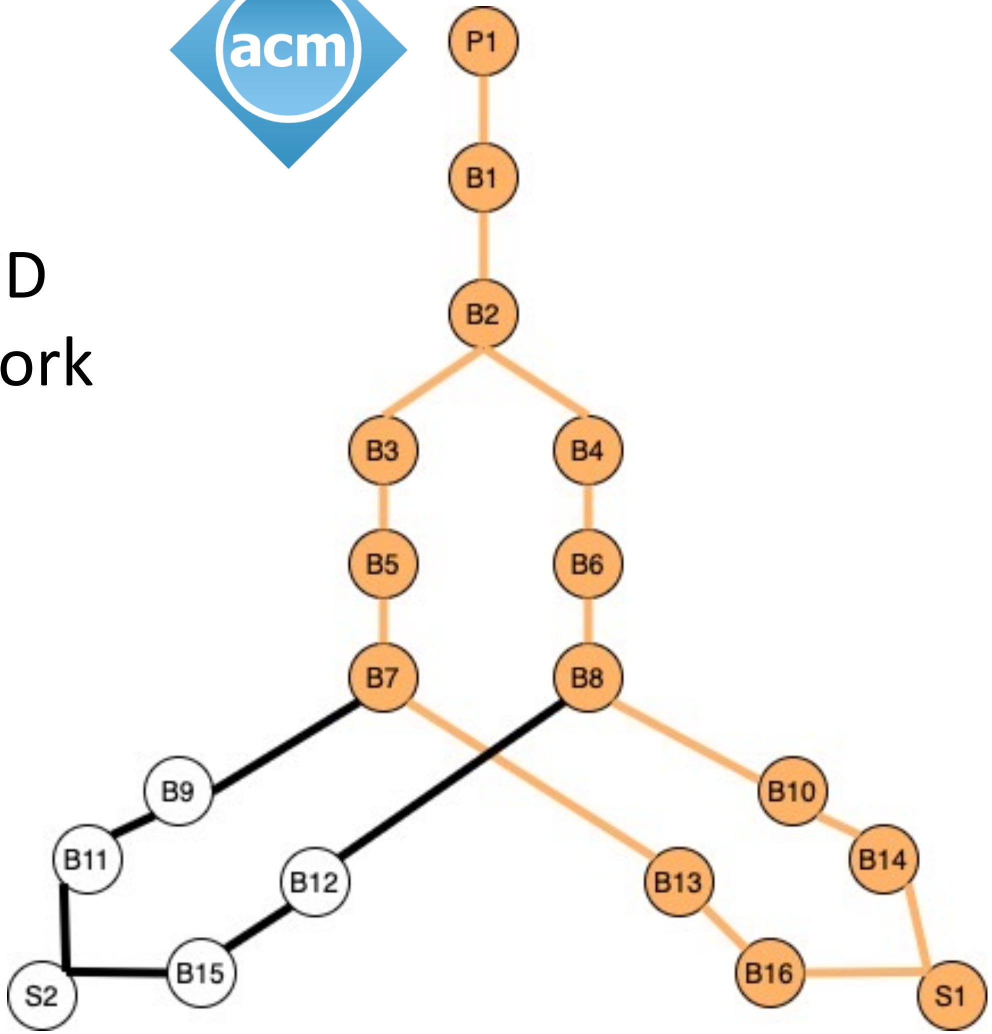
Implementing GFD on a broker network



Subscrition

Alan

Implementing GFD on a broker network



Subscrition

Alan

Implementing GFD
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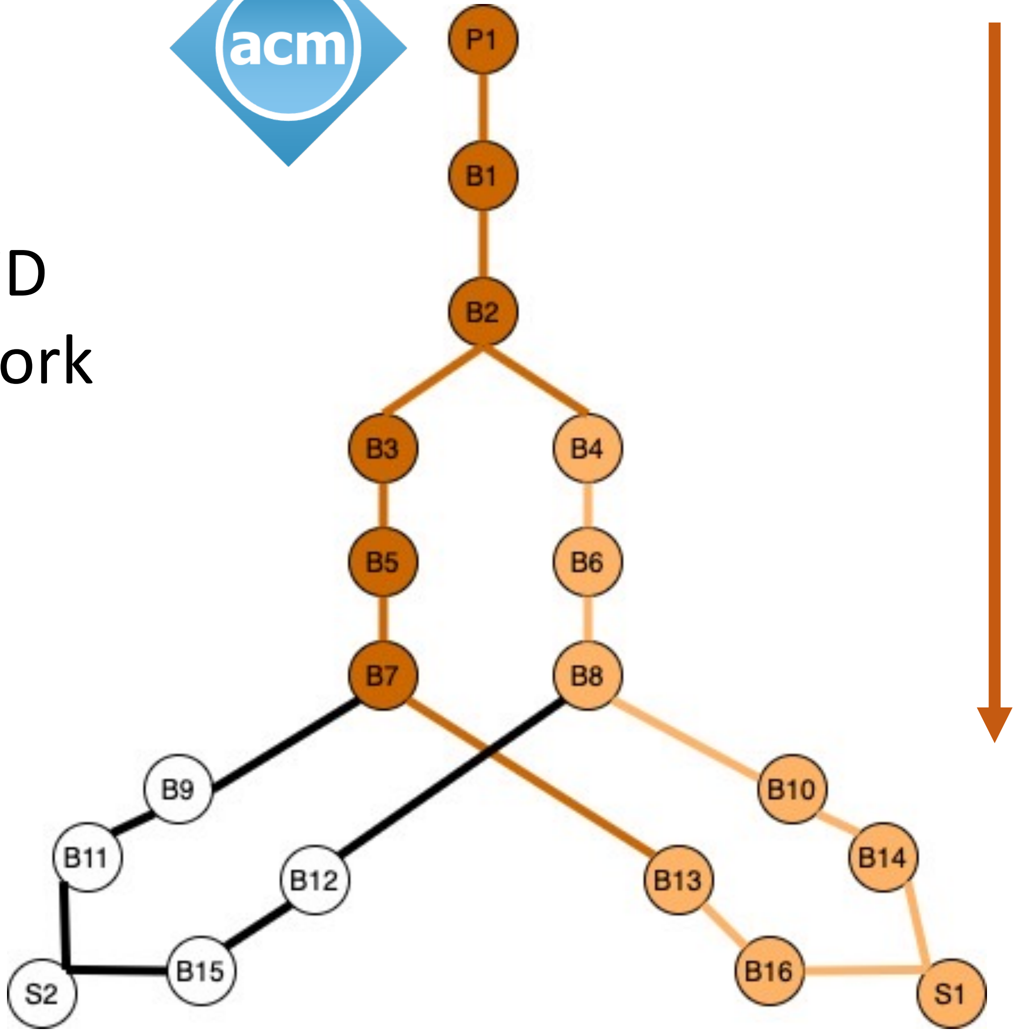
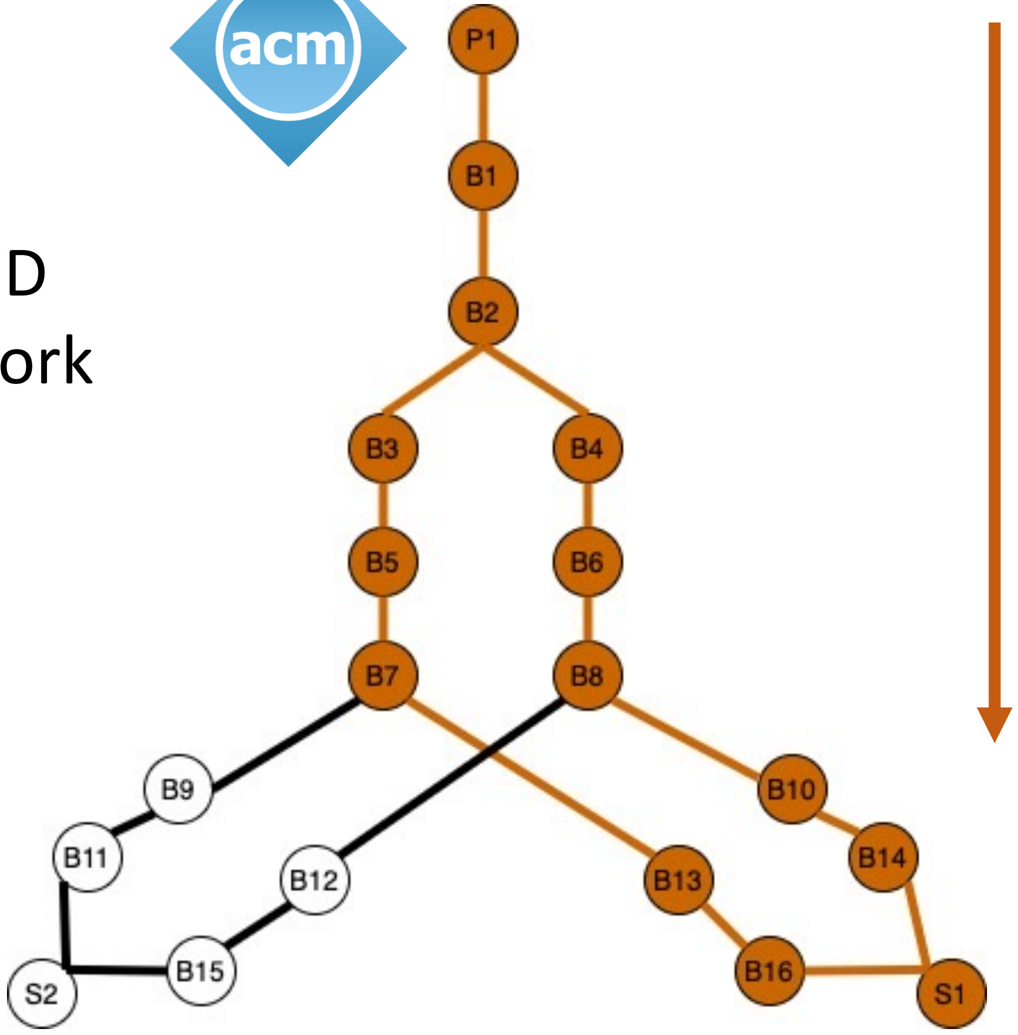


Subscription acknowledgement

Alan

Implementing GFD on a broker network



Subscription acknowledgement

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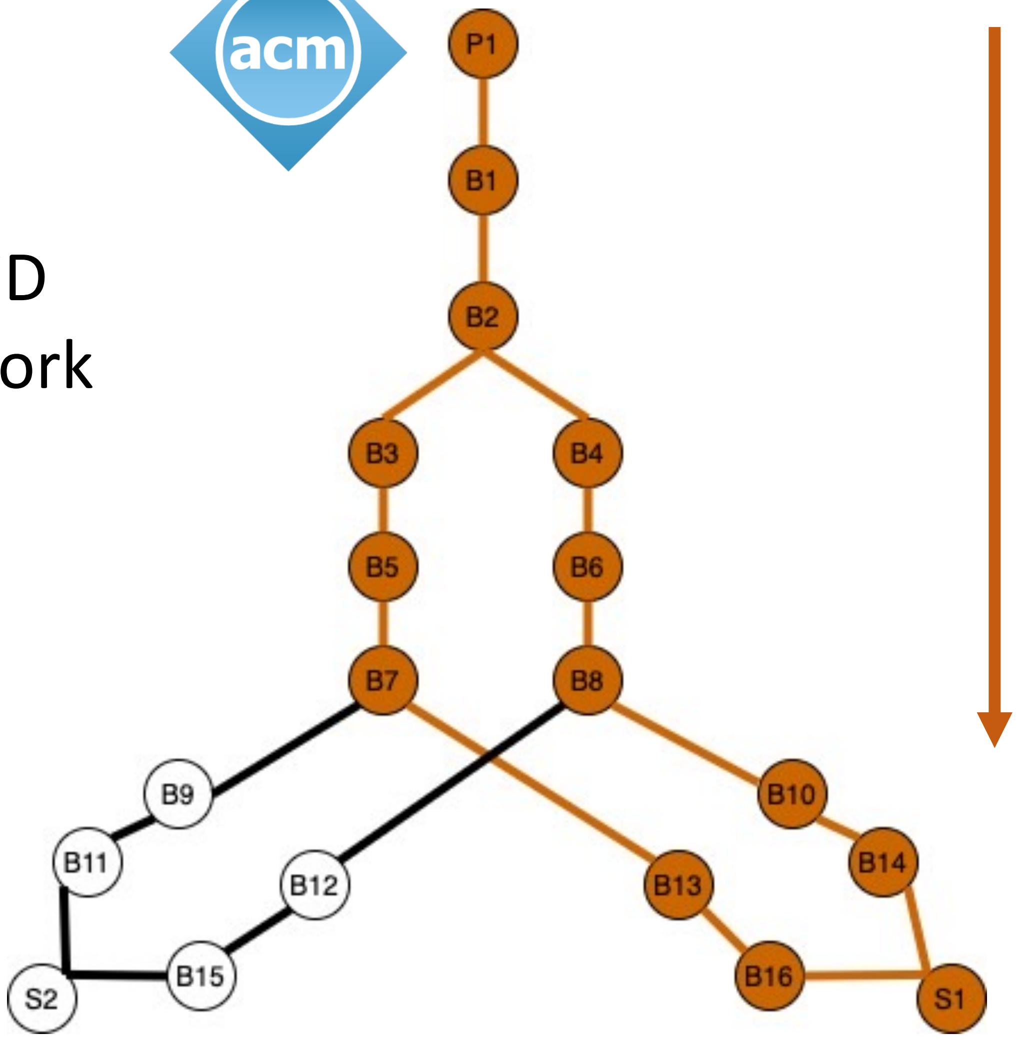
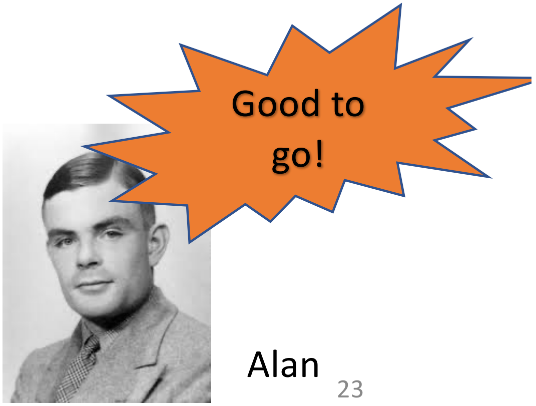
Implementing GFD on a broker network



Subscription acknowledgement



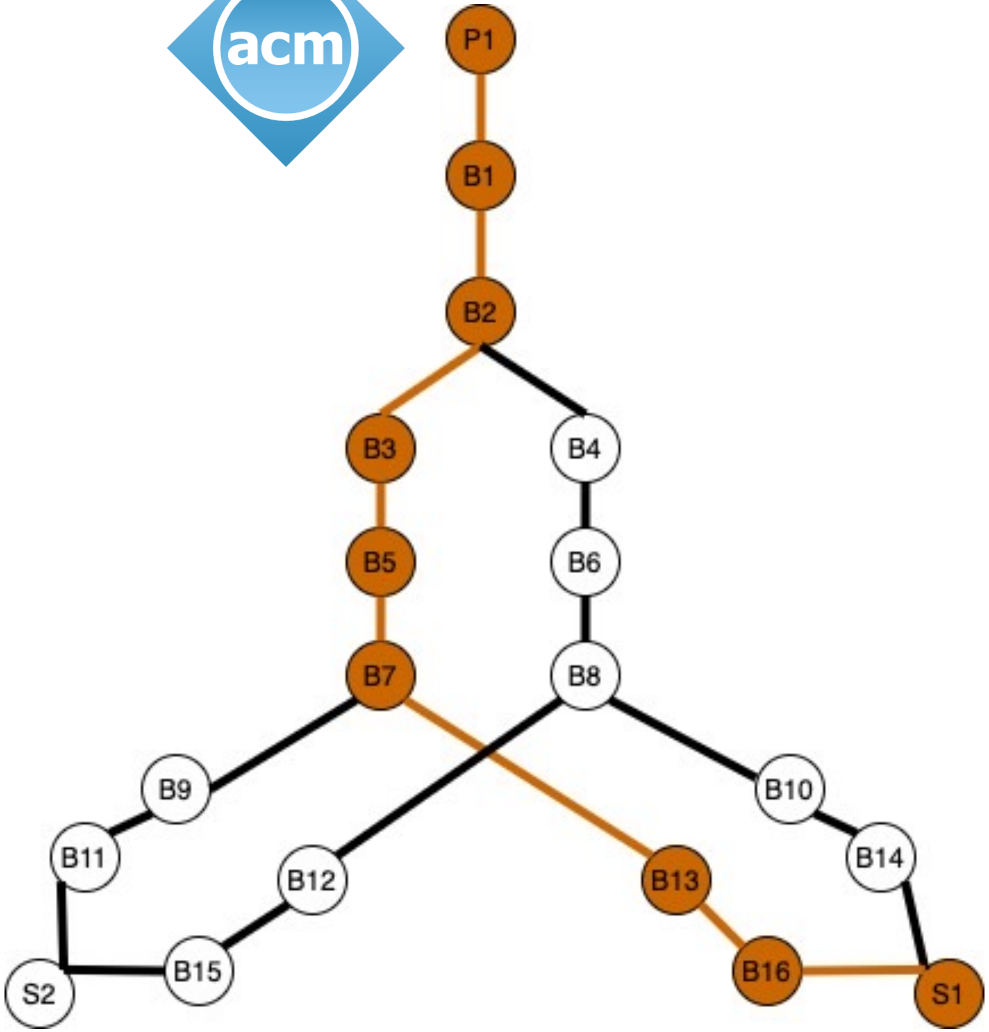
Alan

Enforcing GFD and GCD

- Necessary and sufficient conditions to enforce GFD and GCD.

    - A subscription **is stable on path** if it known by all nodes on that path.

    - **1st Result: For GFD, it is sufficient that ONE path is be stable.**



Good to go!

Alan

Enforcing GFD and GCD

- Necessary and sufficient conditions to enforce GFD and GCD
  - A subscription is stable on path if it known by all nodes on that path.
  - **1st Result: For GFD, it is sufficient that one path is be stable.**
  - **2nd Result: For GCD, it is also sufficient that one path is be stable!**

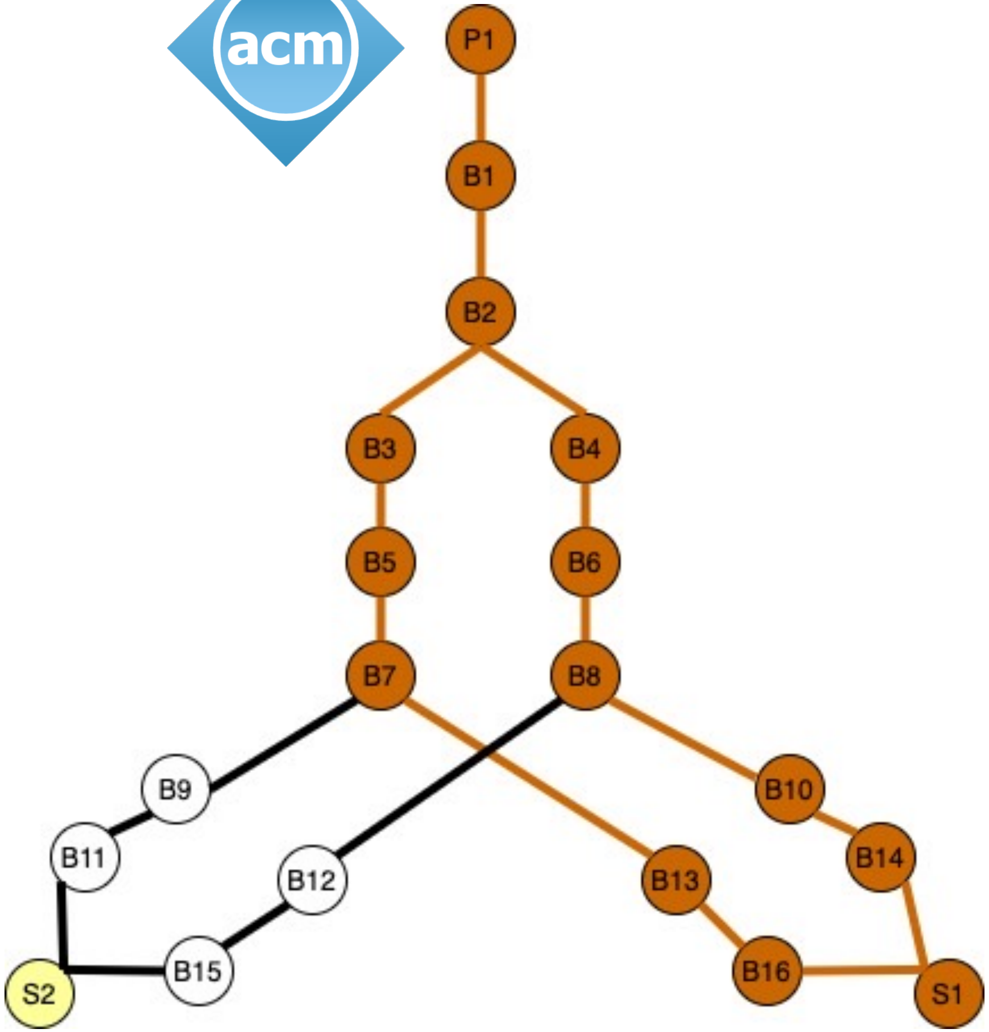
Enforcing GFD and GCD

- Necessary and sufficient conditions to enforce GFD and GCD.
  - A subscription is stable on path if it known by all nodes on that path.
  - **1st Result: For GFD, it is suffic th ath is be stable.**
  - **2nd Result: Fo h is be stable!**

GCD is **NOT** inherently more expensive than GFD!

Leveraging Coverage

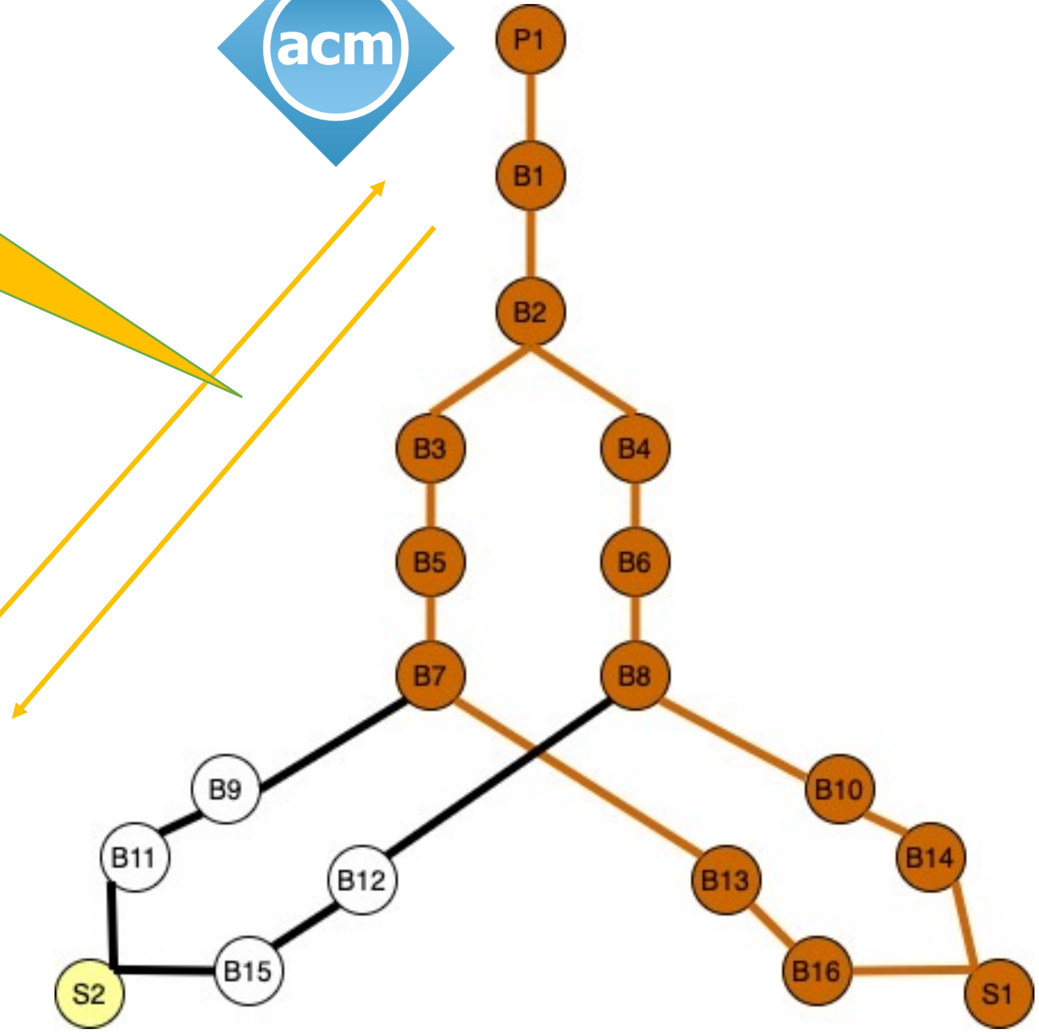
- If another subscription is already in place, can we used it to reduce the subscription latency?



Luís

Alan

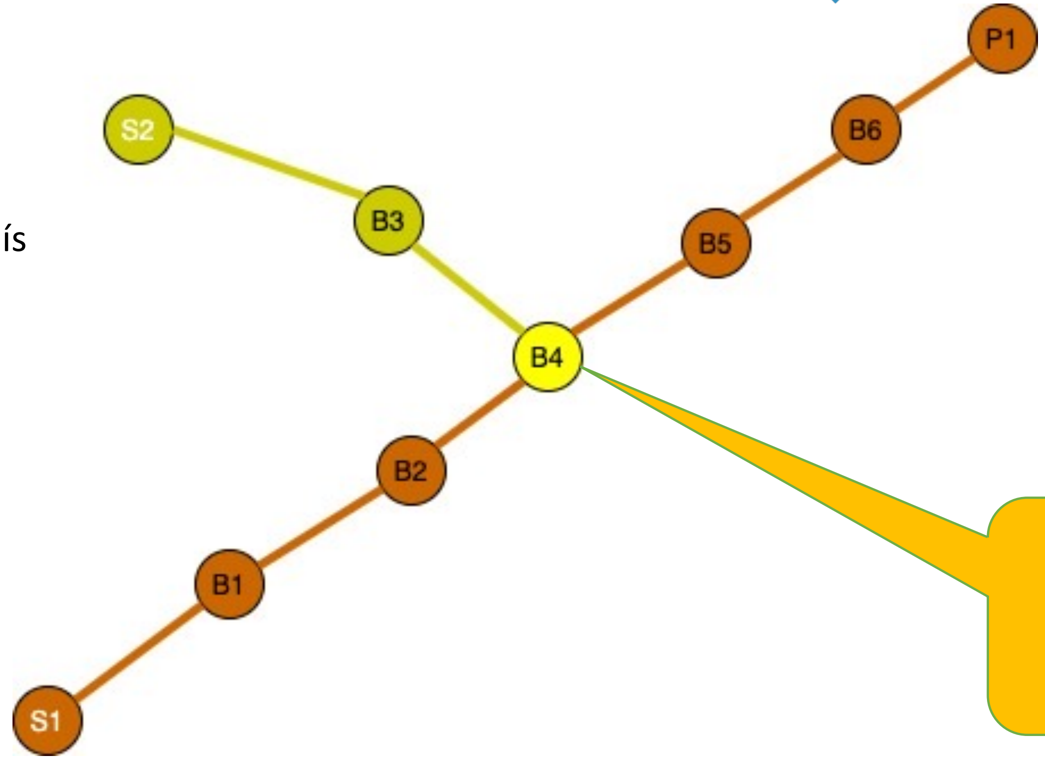
roundtrip to publisher required?



Luís

Alan

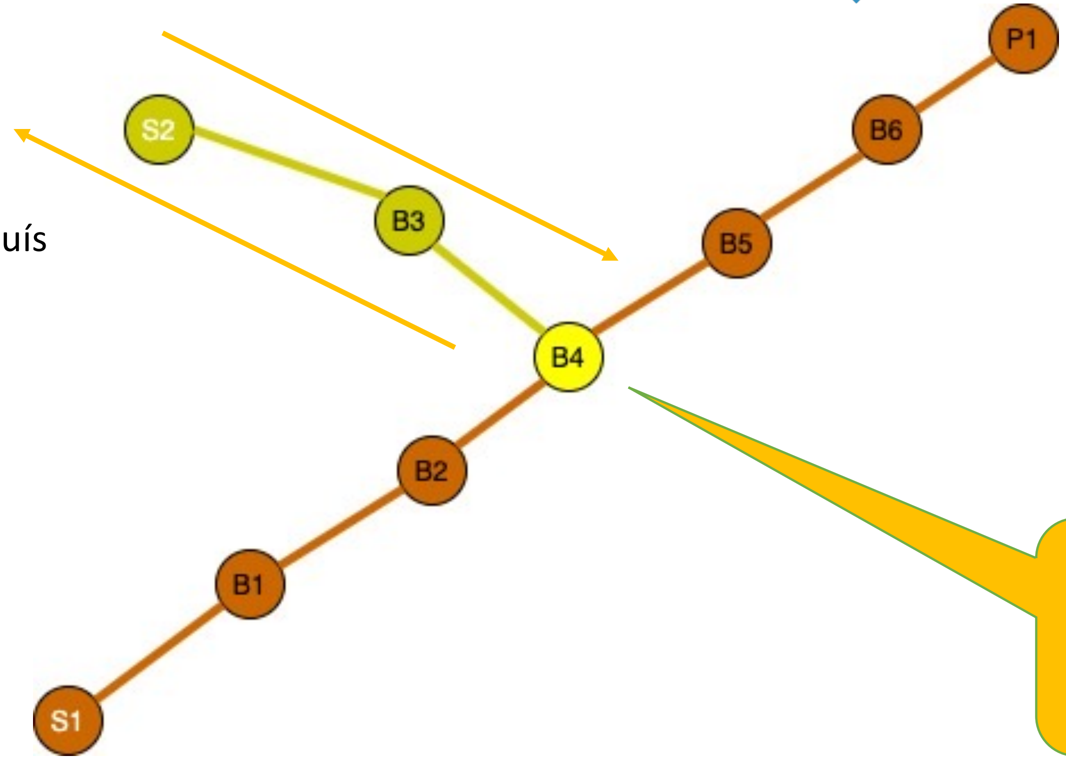
Luís



pivot broker

Alan

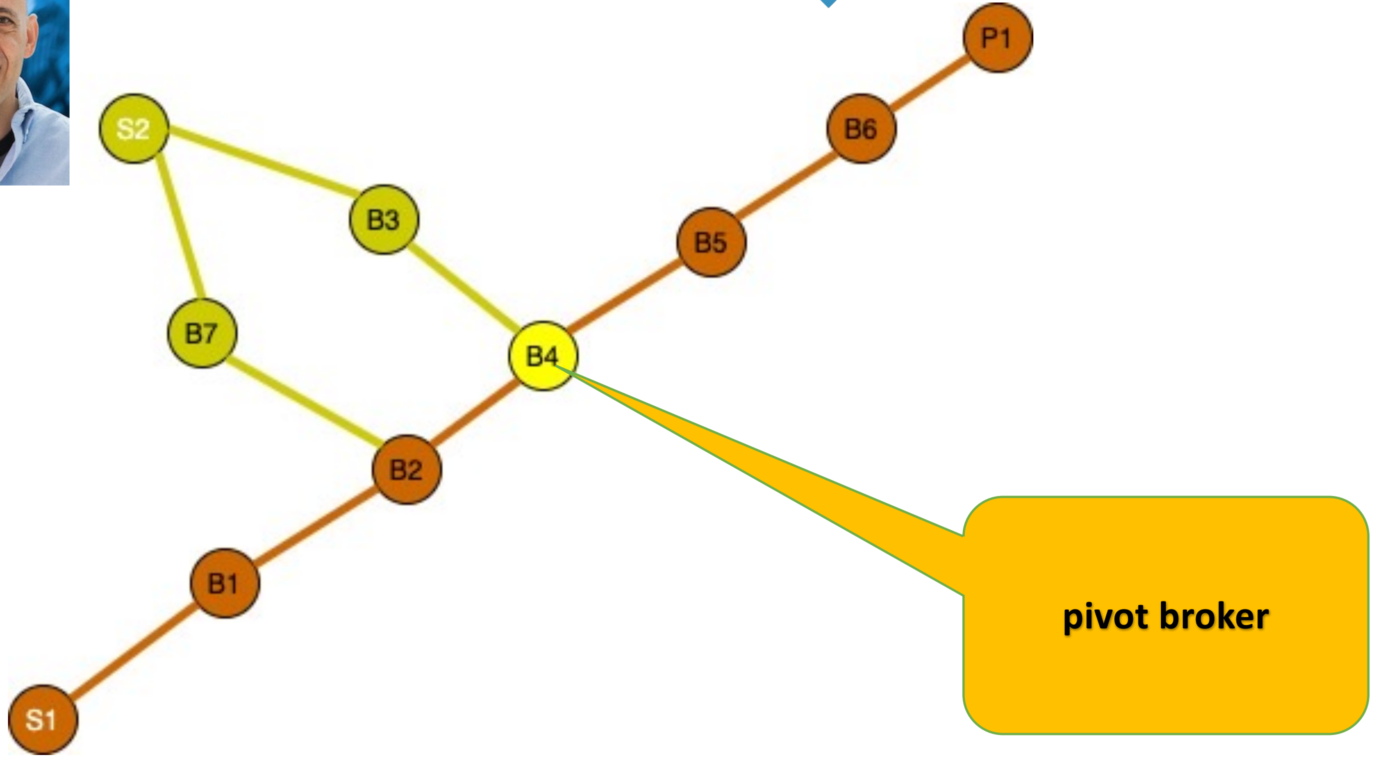
Luís



roundrip to the pivot broker

Alan

Luís



pivot broker

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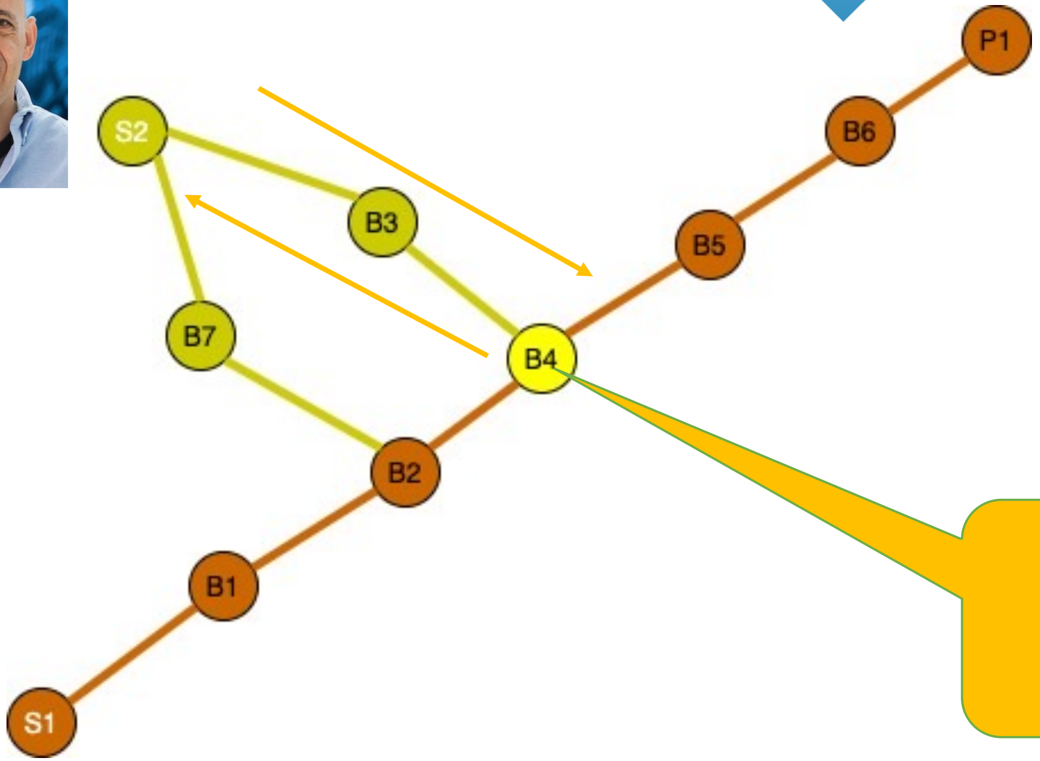

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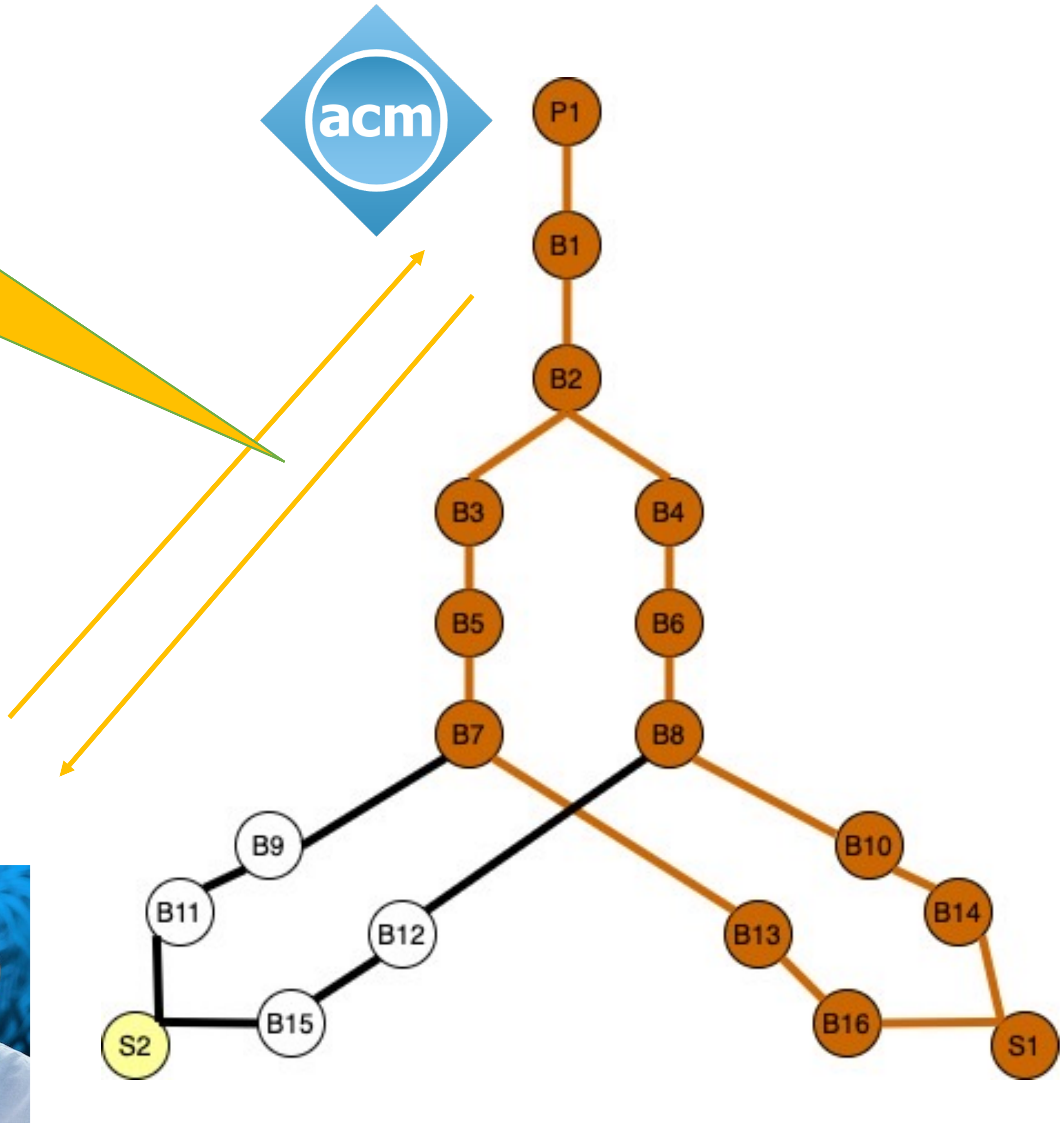
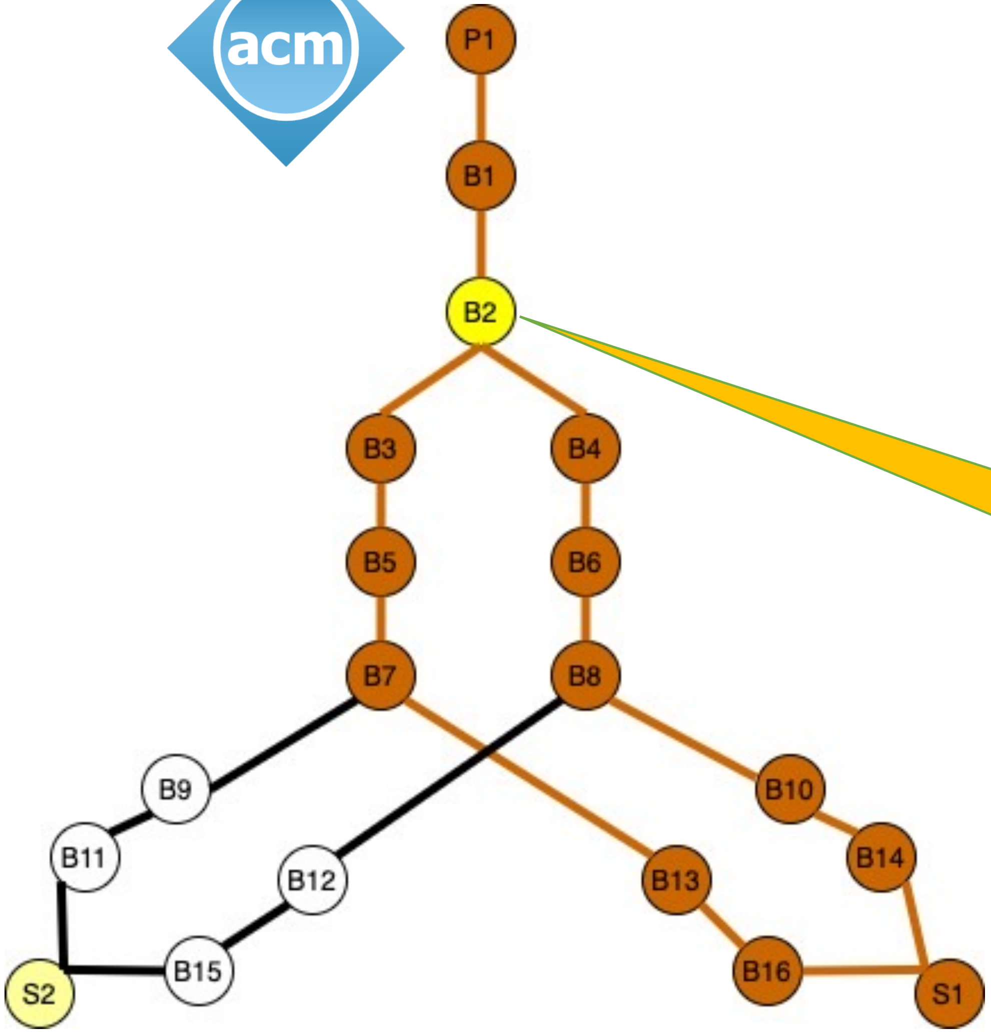


Luís

Alan



pivot broker

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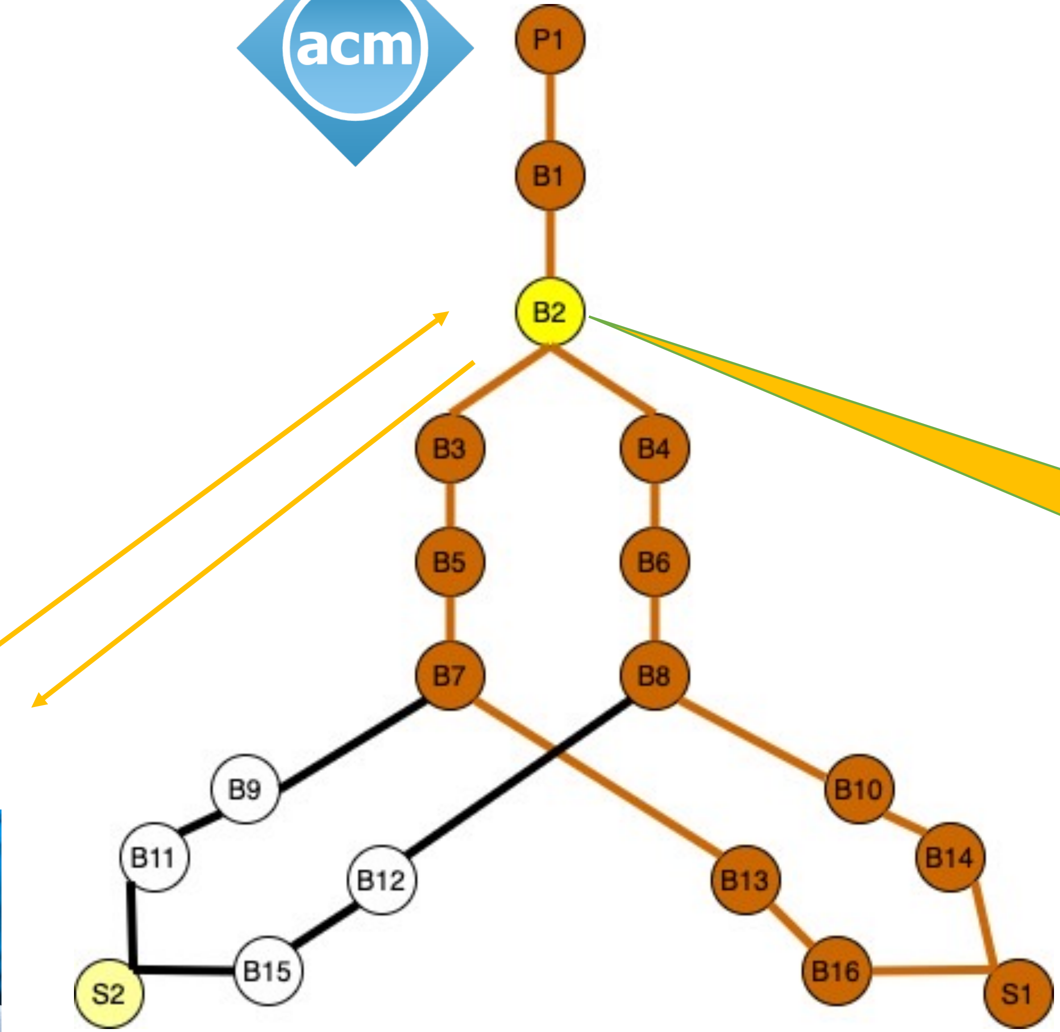
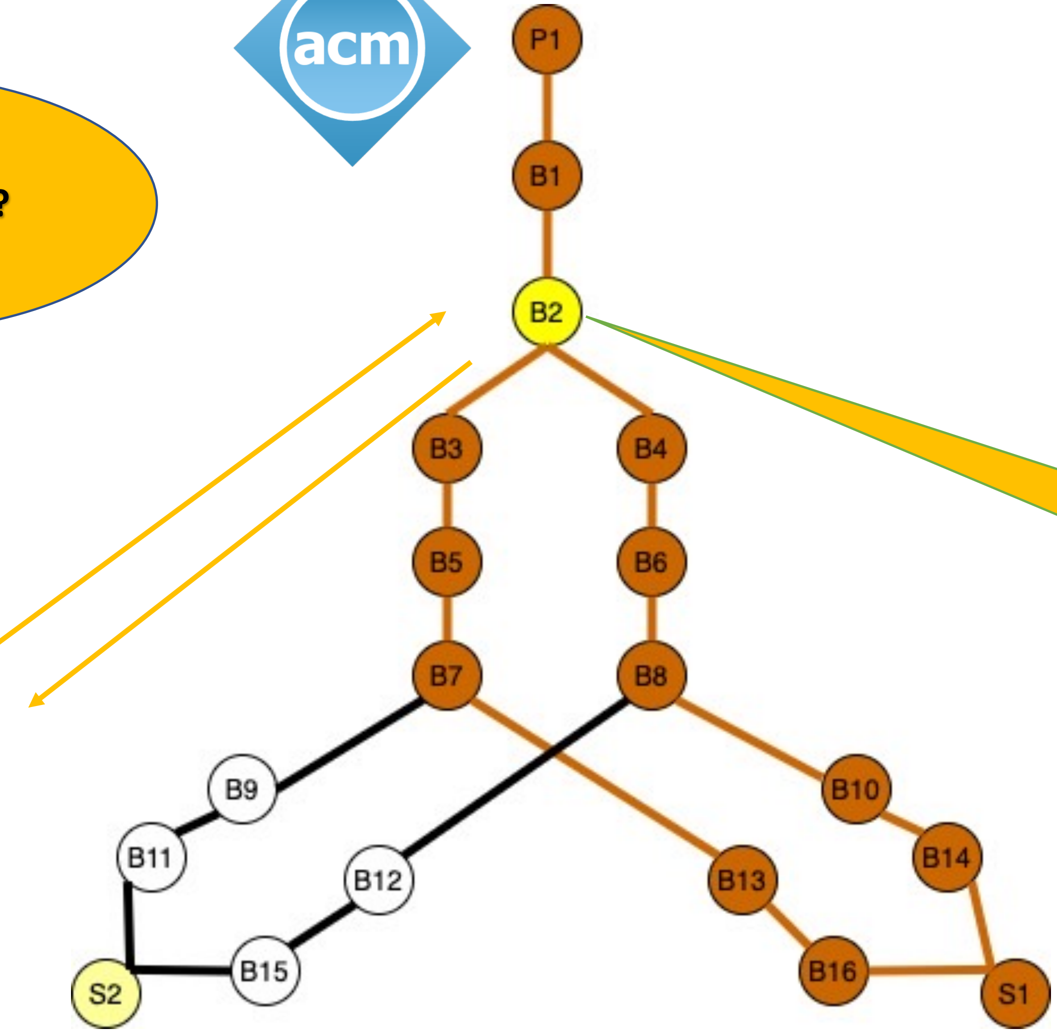


pivot broker

Luís

Alan

Can we do better?

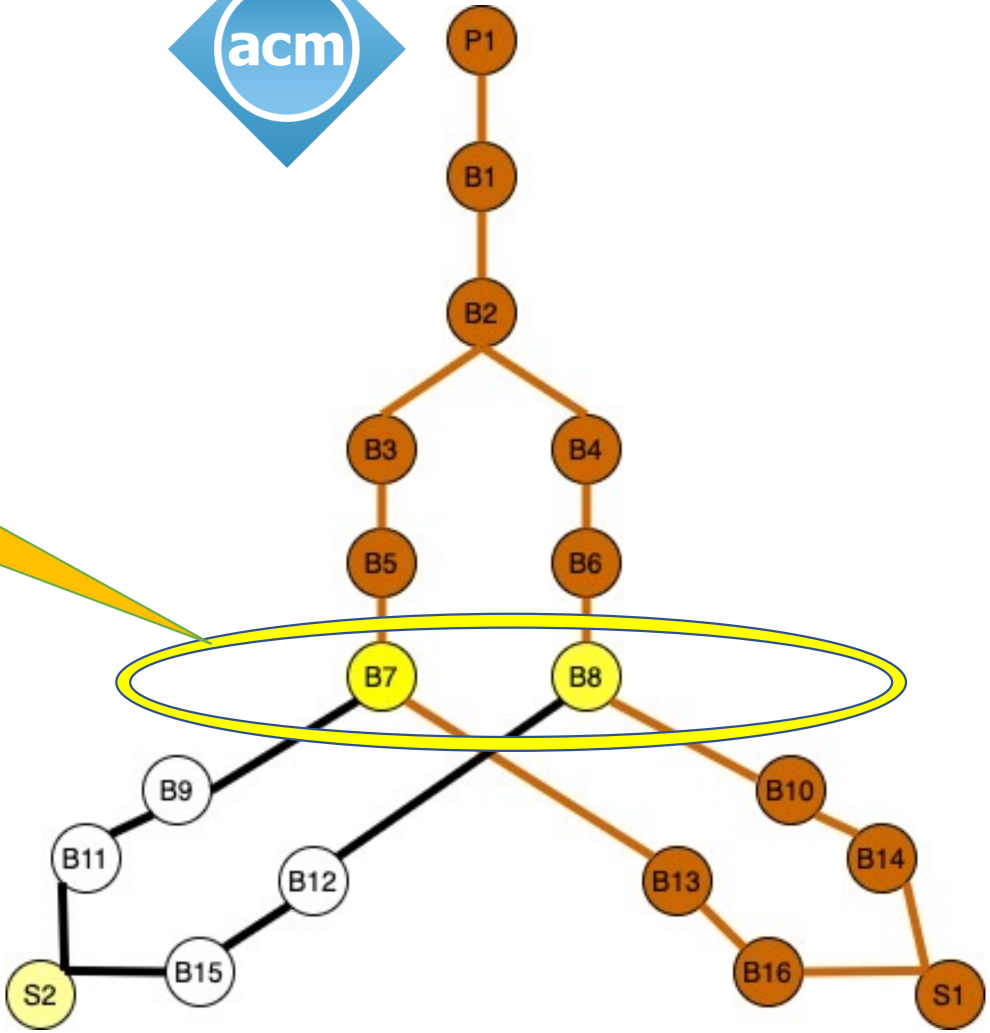


pivot broker

Luís

Alan

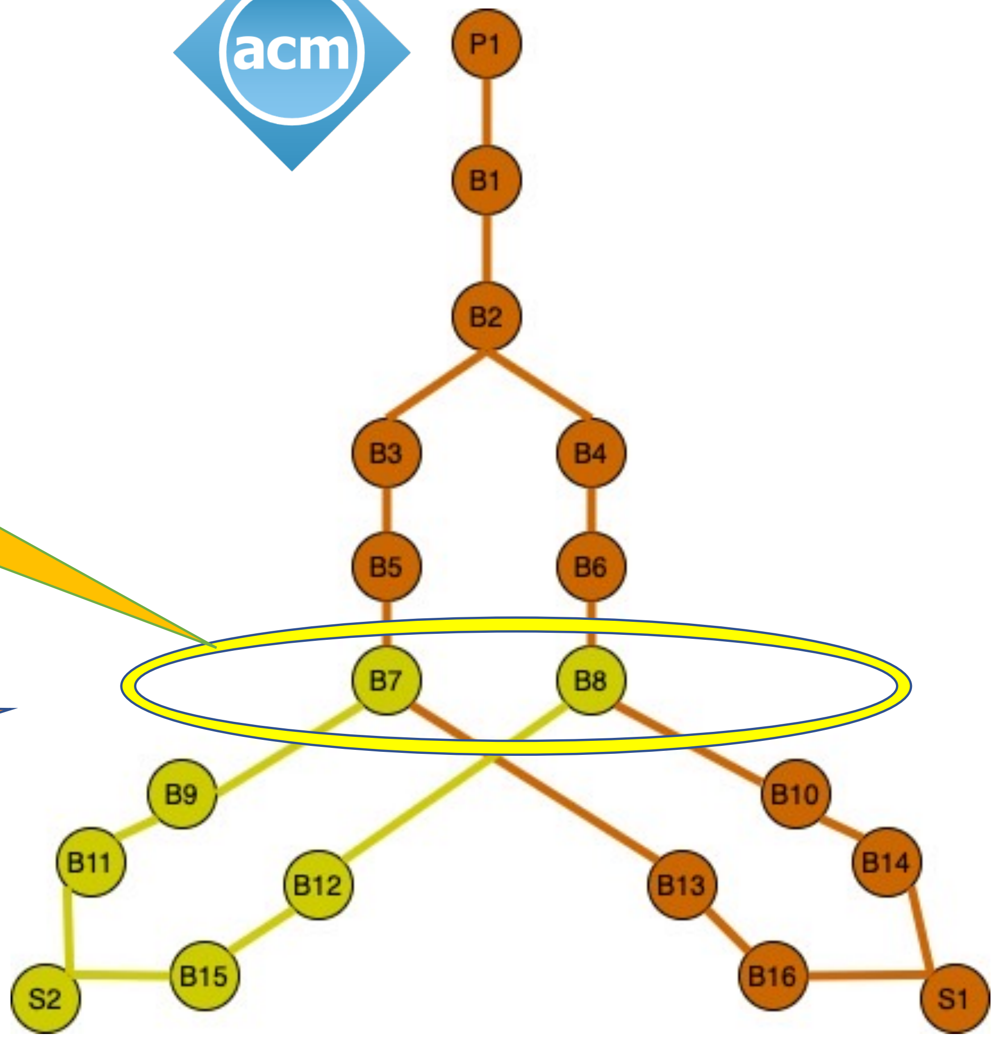
pivot set!



Luís

Alan

pivot set!



Good to go!

Luís

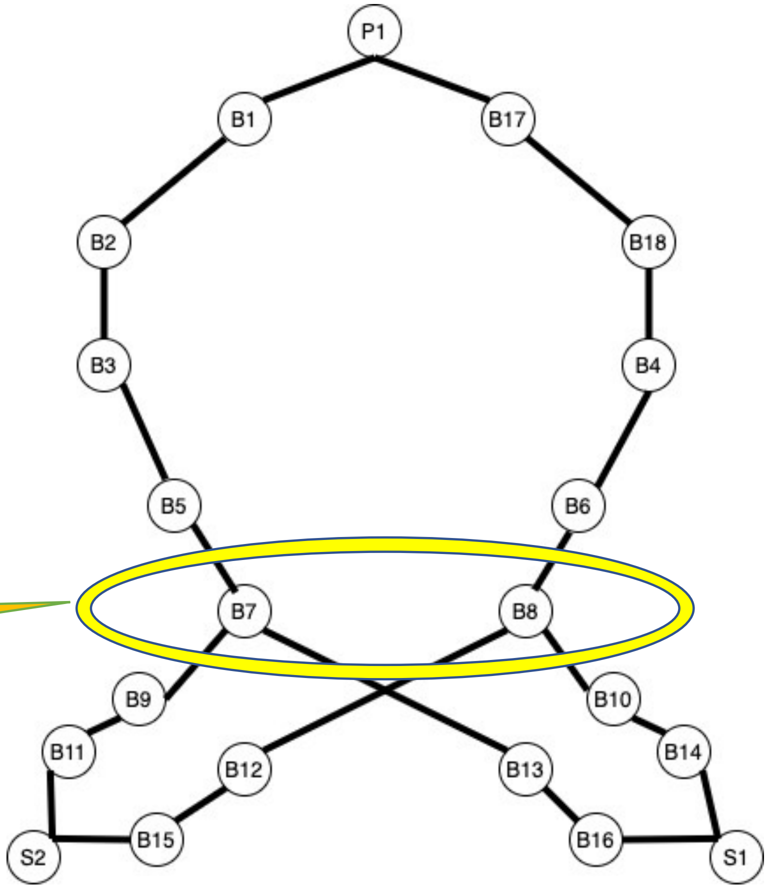
Alan

Publisher, pivot broker, and pivot set

- **Previous works**:
  - Subscription stable on one or more paths to the publisher
- **Our work**: subscription stable on
  - One path to the pivot broker
  - **OR**
  - One path to each member of the pivot set

Relevance of the pivot set

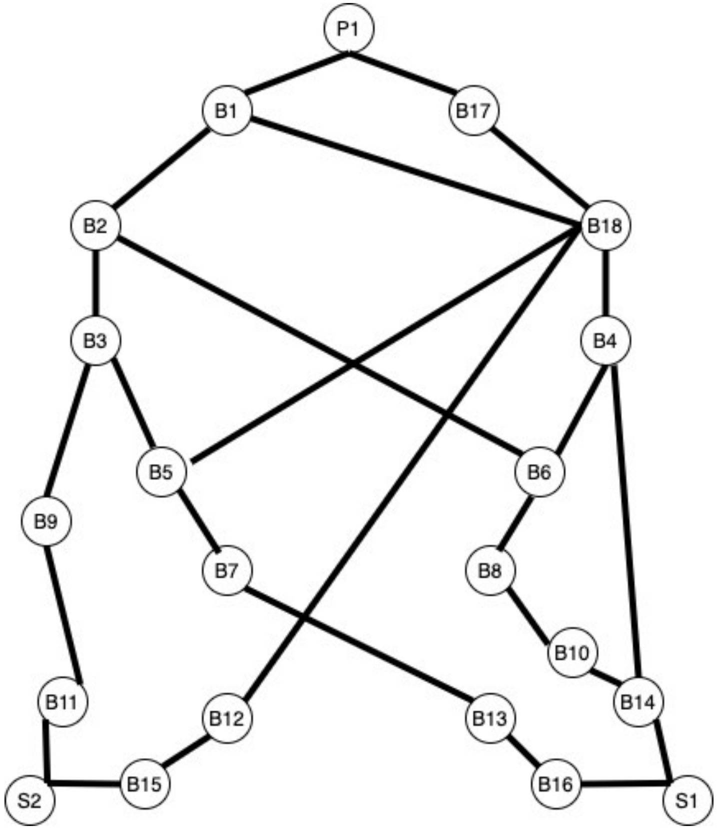
- For fault-tolerance you want to have multiple disjoint paths to the publisher.
- No pivot-broker



pivot set!

Finding the pivot set

- In general graphs it may be hard to find the pivot set.

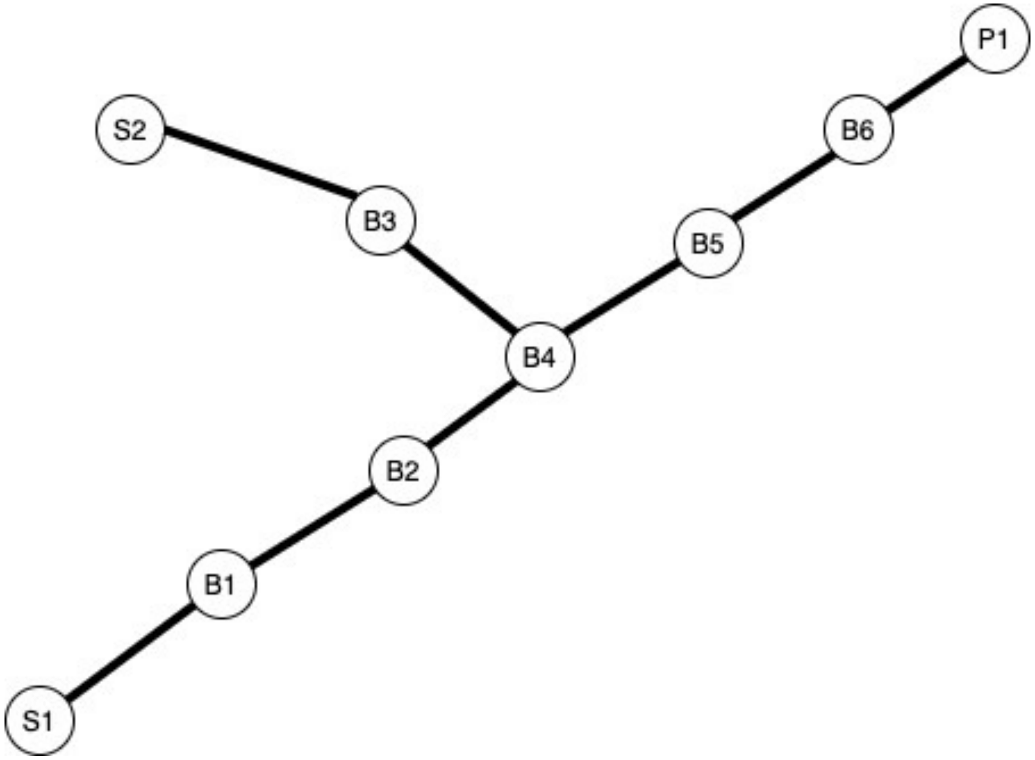


LoCaPS

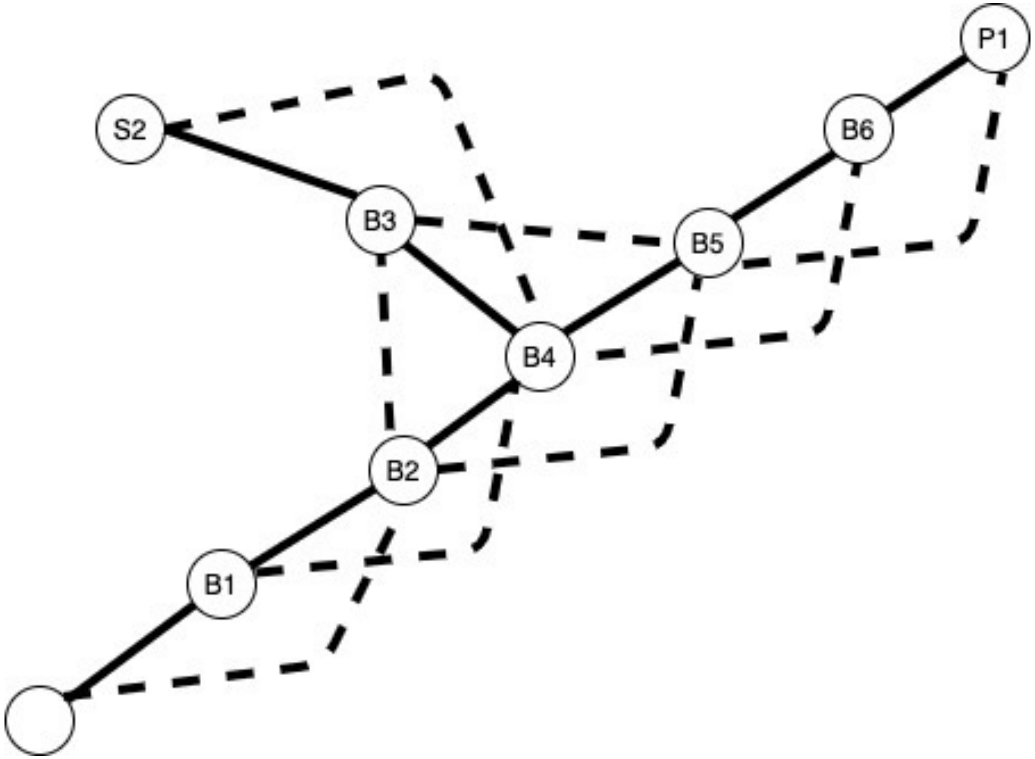
- LoCaPS: publish-subscribe implementation that leverages our findings.

- It is possible to build the broker overlay that is fault-tolerant and where it is easy to find the pivot-set.

LoCaPS



LoCaPS



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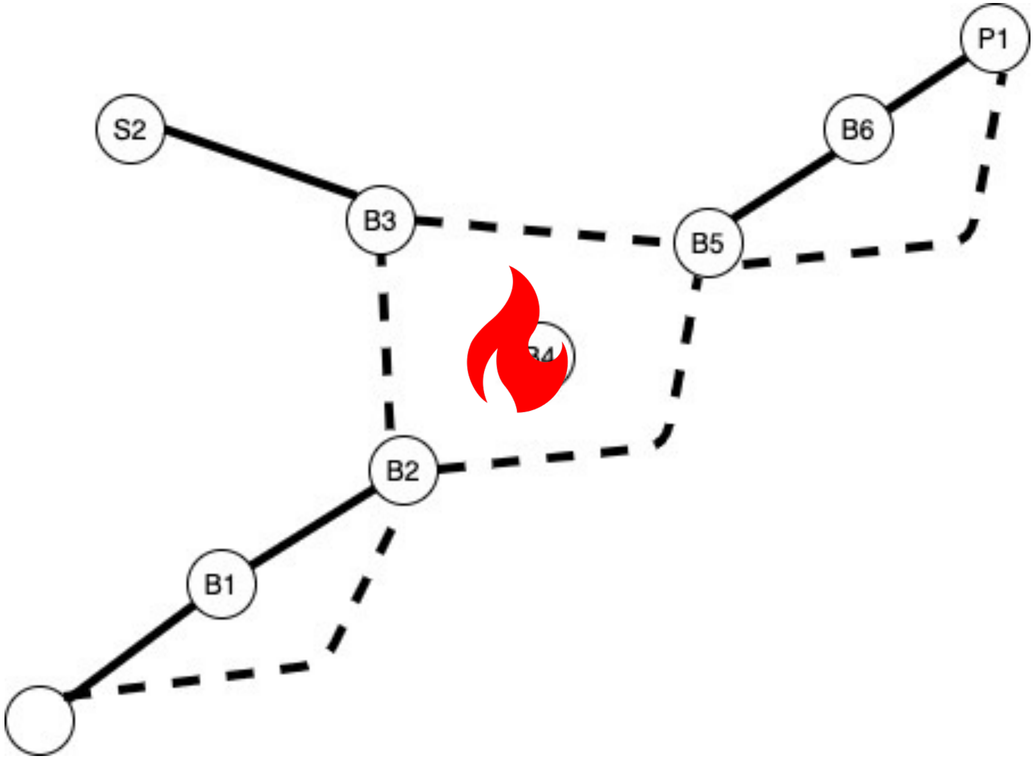
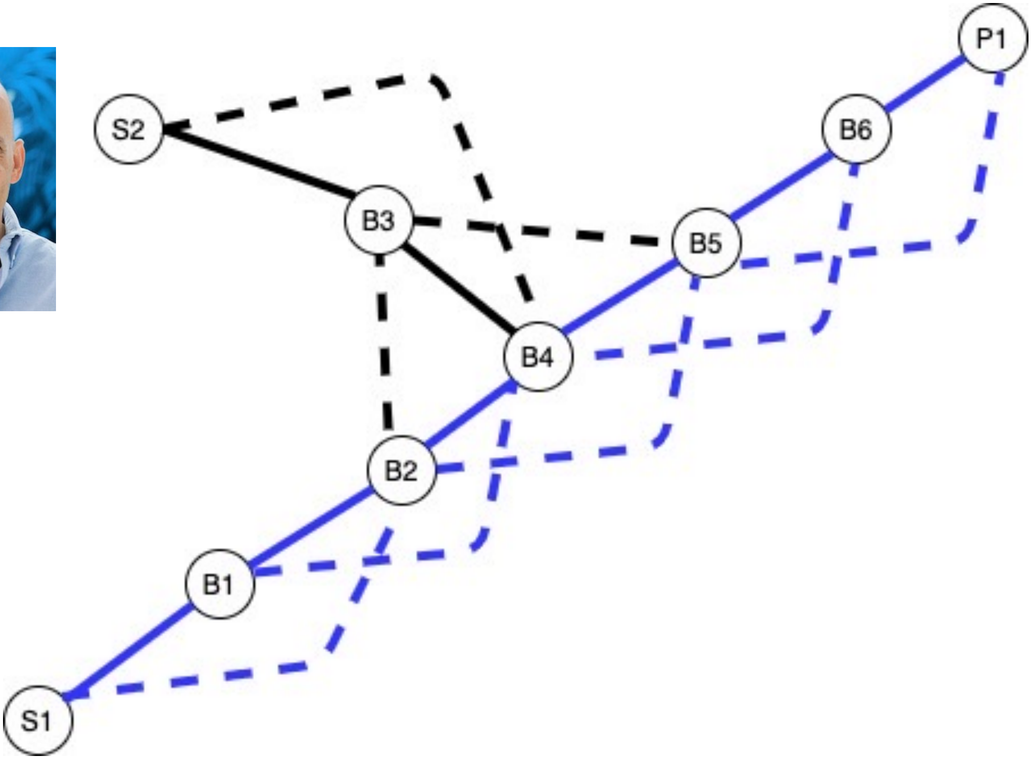


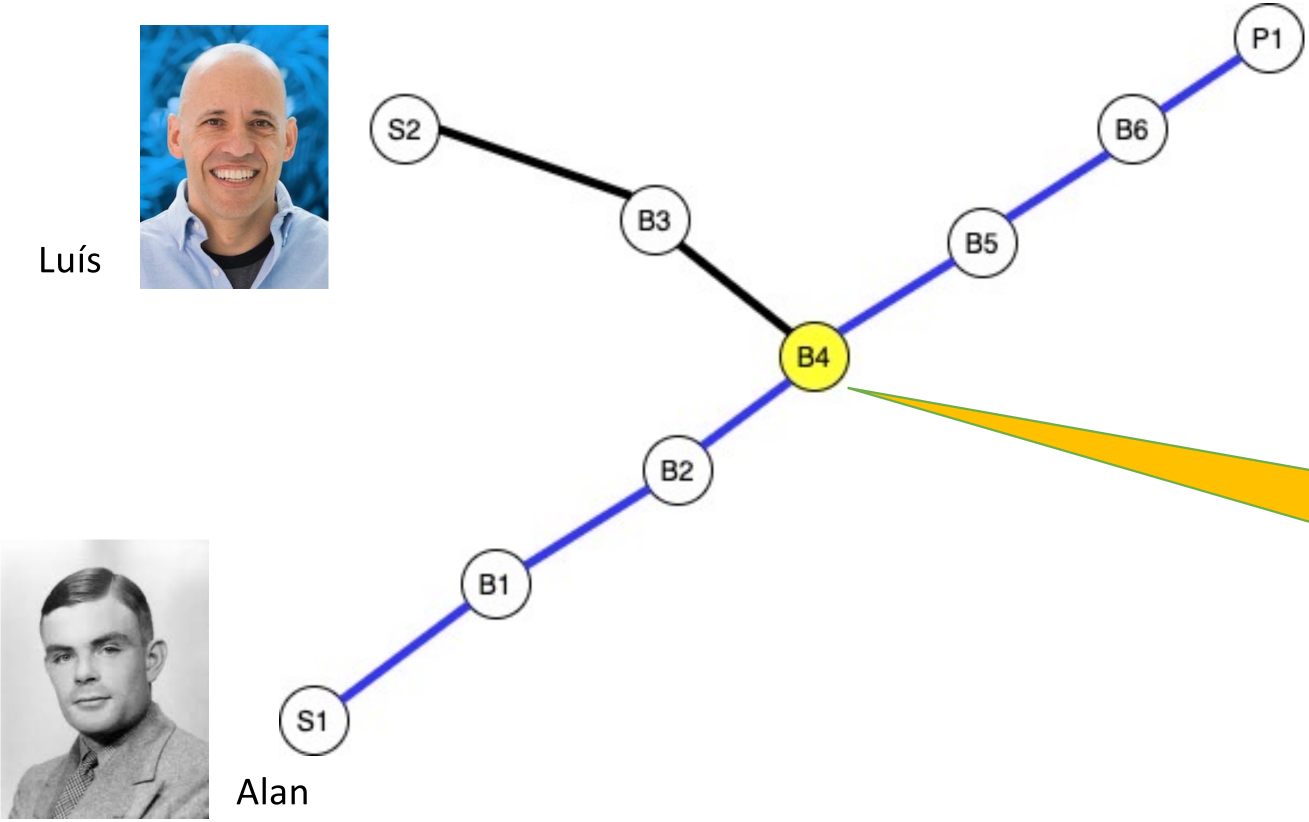
LoCaPS

Luís



Alan

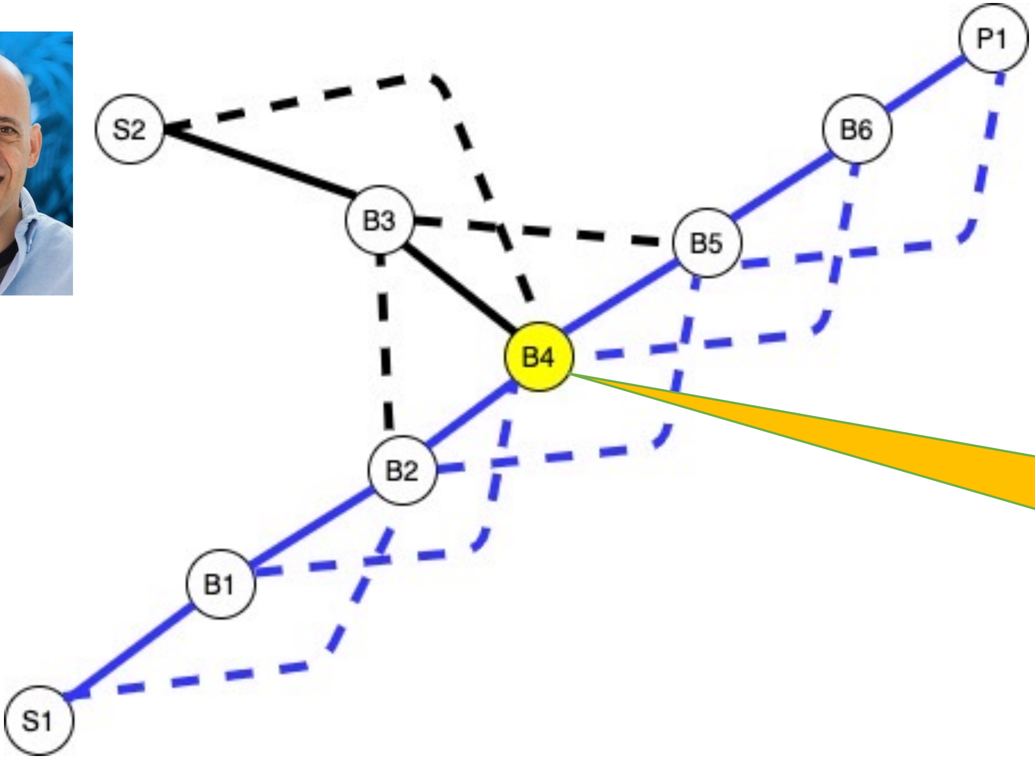
LoCaPS



pivot broker in the base graph

LoCaPS

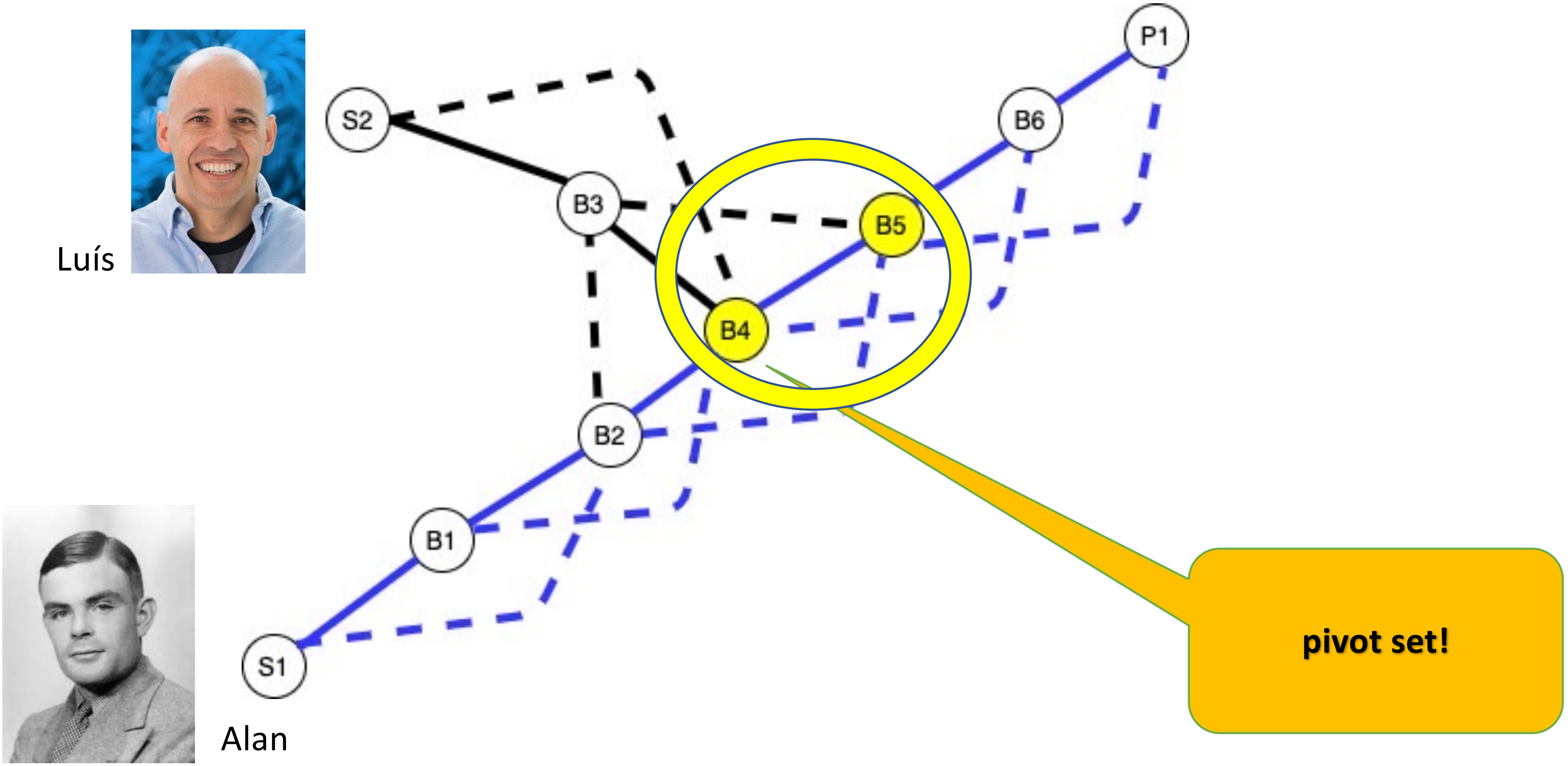
Luís



pivot broker in the base graph

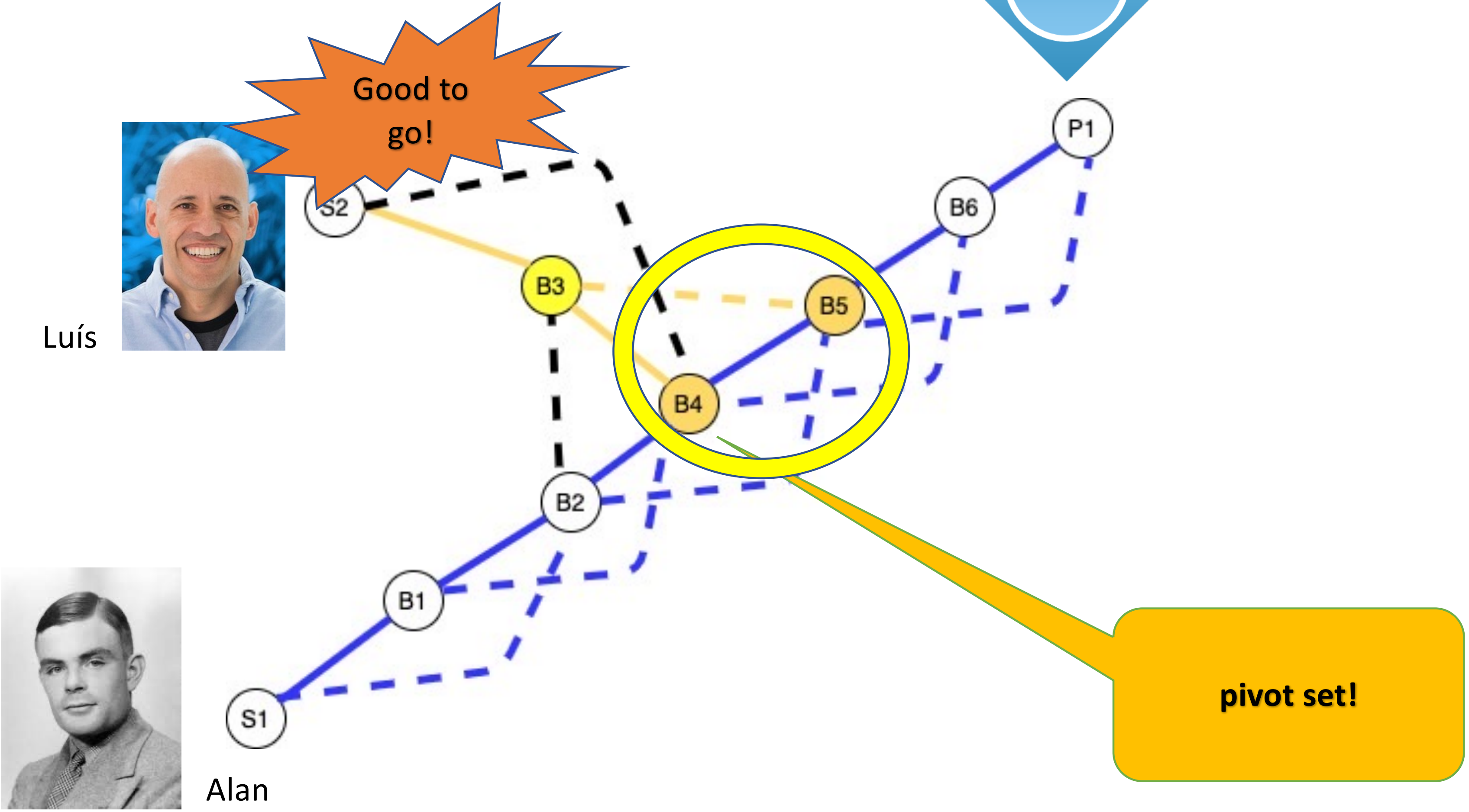
Alan

LoCaPS



pivot set!

LoCaPS



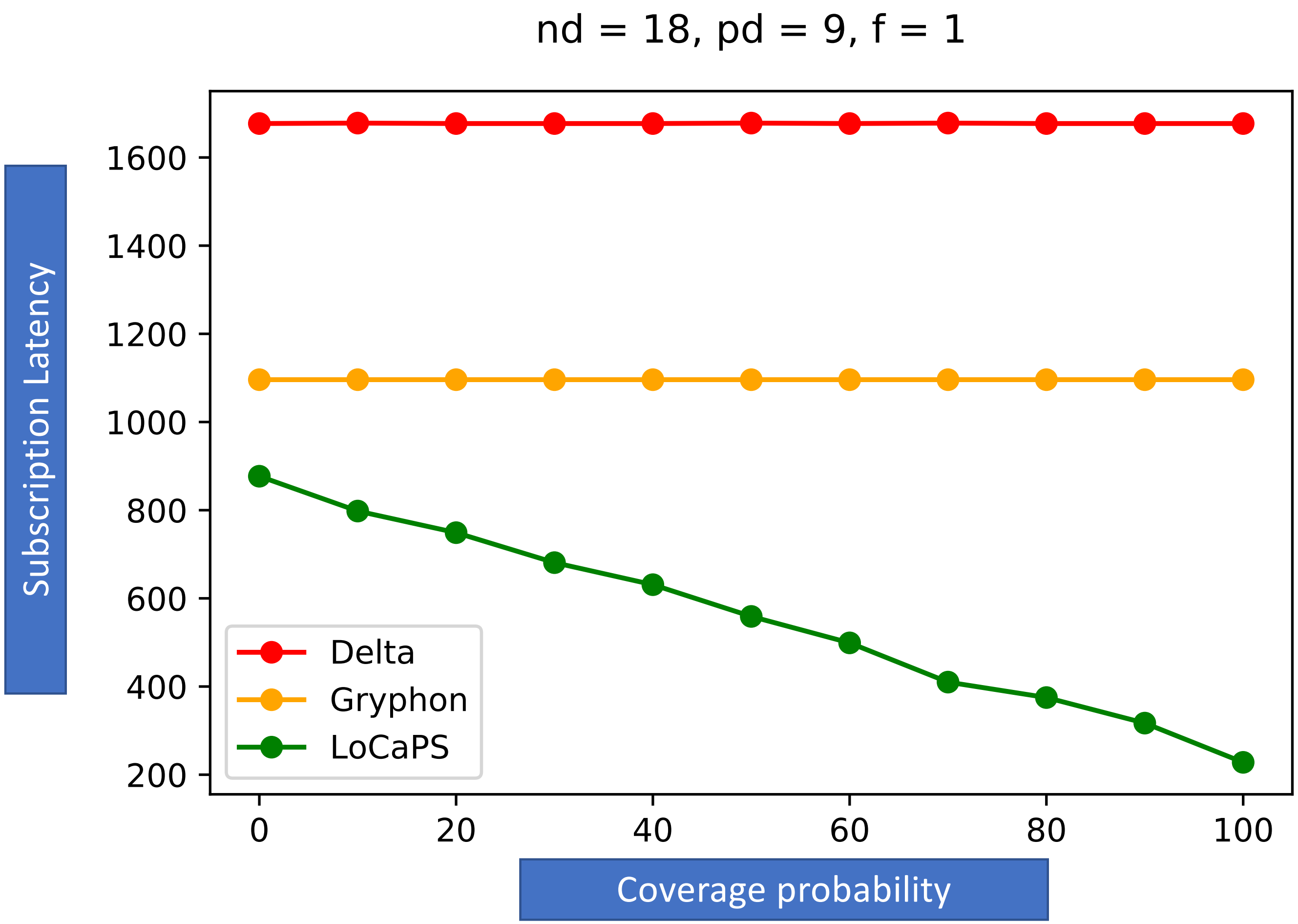
Good to go!

pivot set!

LoCaPS

- Evaluation against:
  - Delta: R. Kazemzadeh and H. Jacobsen. 2011. Partition-tolerant distributed publish/subscribe systems. In SRDS. IEEE, Madrid, Spain.
  - Gryphon: Y. Zhao, D. Sturman, and S. Bhola. 2004. Subscription Propagation in Highly-Available Publish/Subscribe Middleware. In Middleware. ACM, Toronto, Canada.

LoCaPS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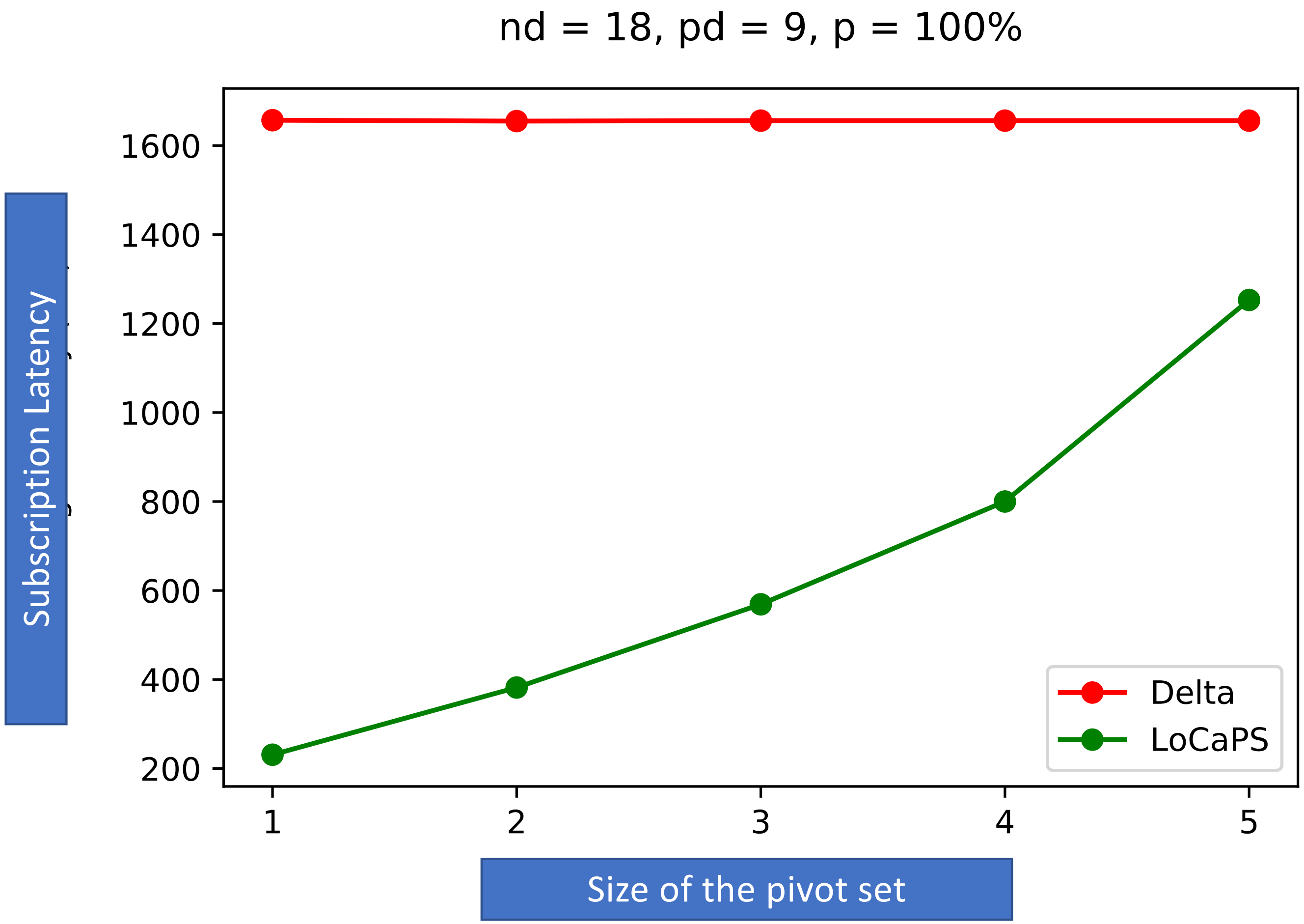
Subscription Latency
1600
1400
1200
1000
800
600
400
200
0
20
40
60
80
100
Coverage probability
Delta
Gryphon
LoCaPS

LoCaPS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Subscription Latency
1600
1400
1200
1000
800
600
400
200
1
2
3
4
5
Size of the pivot set
Delta
LoCaPS

Conclusions

- We have studied the necessary and sufficient conditions that need to be met to offer different reliability semantics to subscribers, namely Gapless FIFO delivery and Gapless Causal delivery.
- We shown that Gapless Causal delivery can be implemented as efficiently as Gapless FIFO delivery.
- Unlike previous systems, LoCaPS can leverage existing subscriptions to reduce the latency of a new subscription.

- **More details and more evaluation results on the paper!**