Router-supported Data Regeneration for In-networked Storage Systems

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◆ In-network storage systems work as a part of or provide storage services to applications, *e.g.*,

- content delivery,
- P2P video streaming, and
- cloud computing.

◆ Decoupling data storage with applications, in-network storage systems should also maintain the data integrity.

- peers may leave the network, resulting in data losses
- store redundancy to compensate for the data losses
- use erasure codes to achieve high data integrity
  - any k among n coded blocks can recover the original data

Drawbacks of erasure codes

◆ High traffic

- must get k blocks to regenerate only **one** block
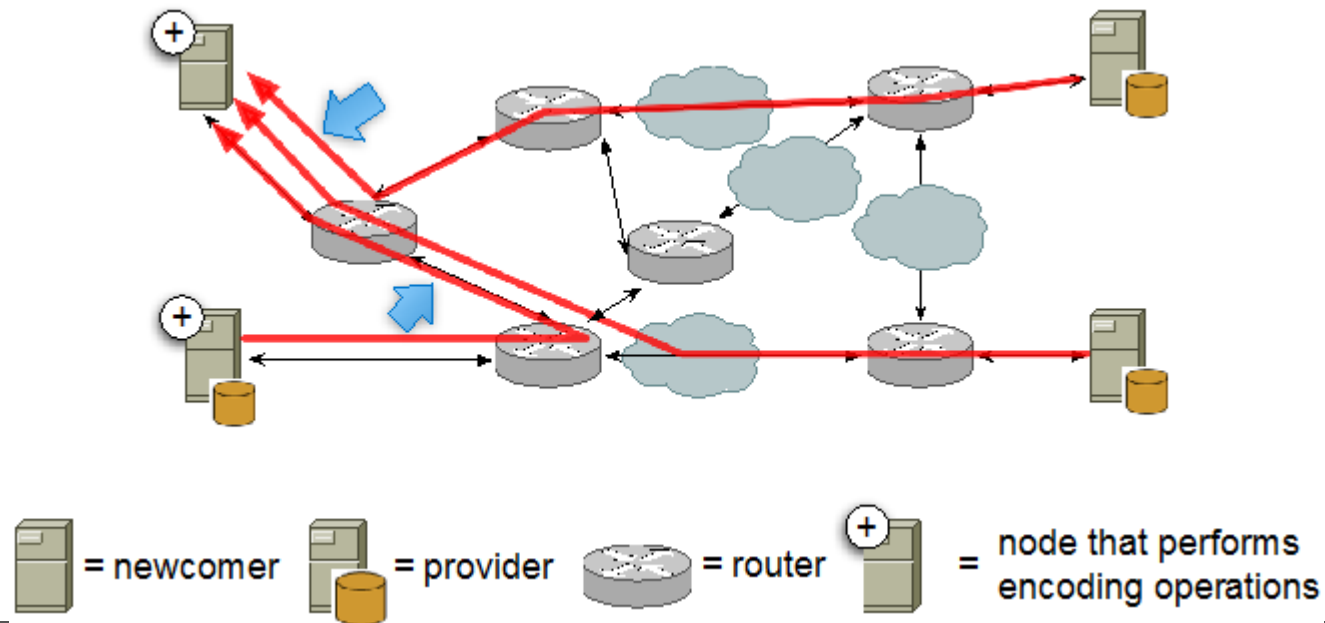
◆ Severe bandwidth bottleneck

= newcomer   = provider

= node that performs encoding operations

Drawbacks of erasure codes

◆ High traffic

    ○ must get k blocks to regenerate only **one** block

◆ Severe bandwidth bottleneck

= newcomer   = provider   = router   = node that performs encoding operations
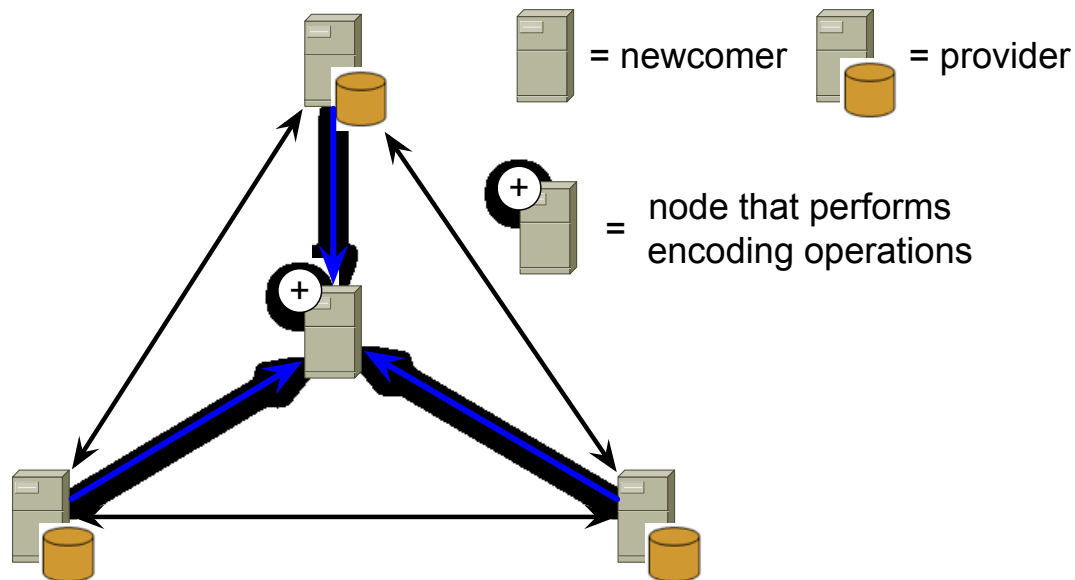
Routers can help!

◆ Supporting routers

- encode data instead of peers during the regeneration;
- route packets as conventional routers; and
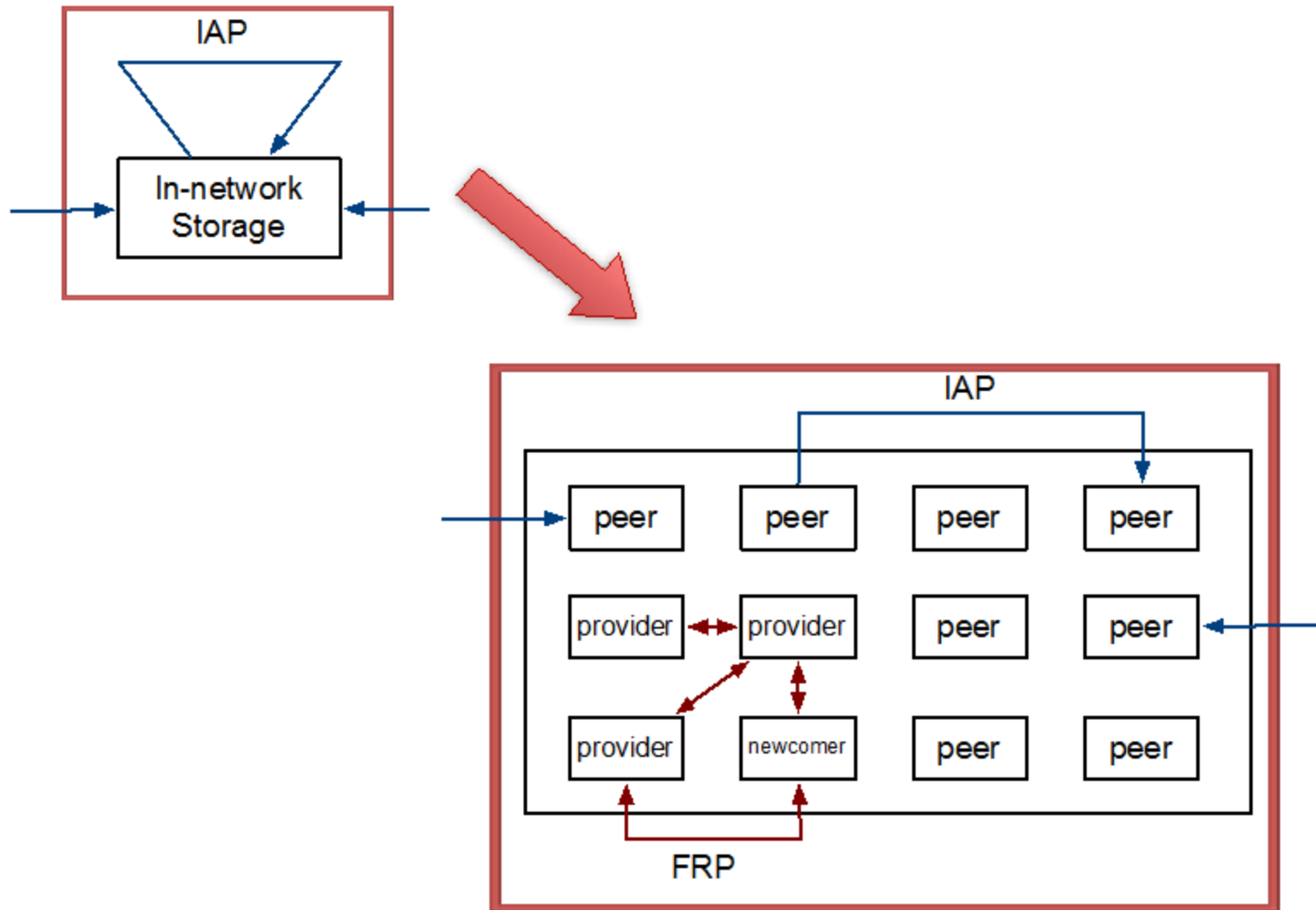- coexist with conventional routers.

◆ File regeneration protocol (FRP)

- supporting router gets information about regeneration from FRP

File Regeneration Protocol (FRP)

IAP

In-network Storage

IAP

IAP

P2P App Clients

Content Publishers

P2P App Native Protocol
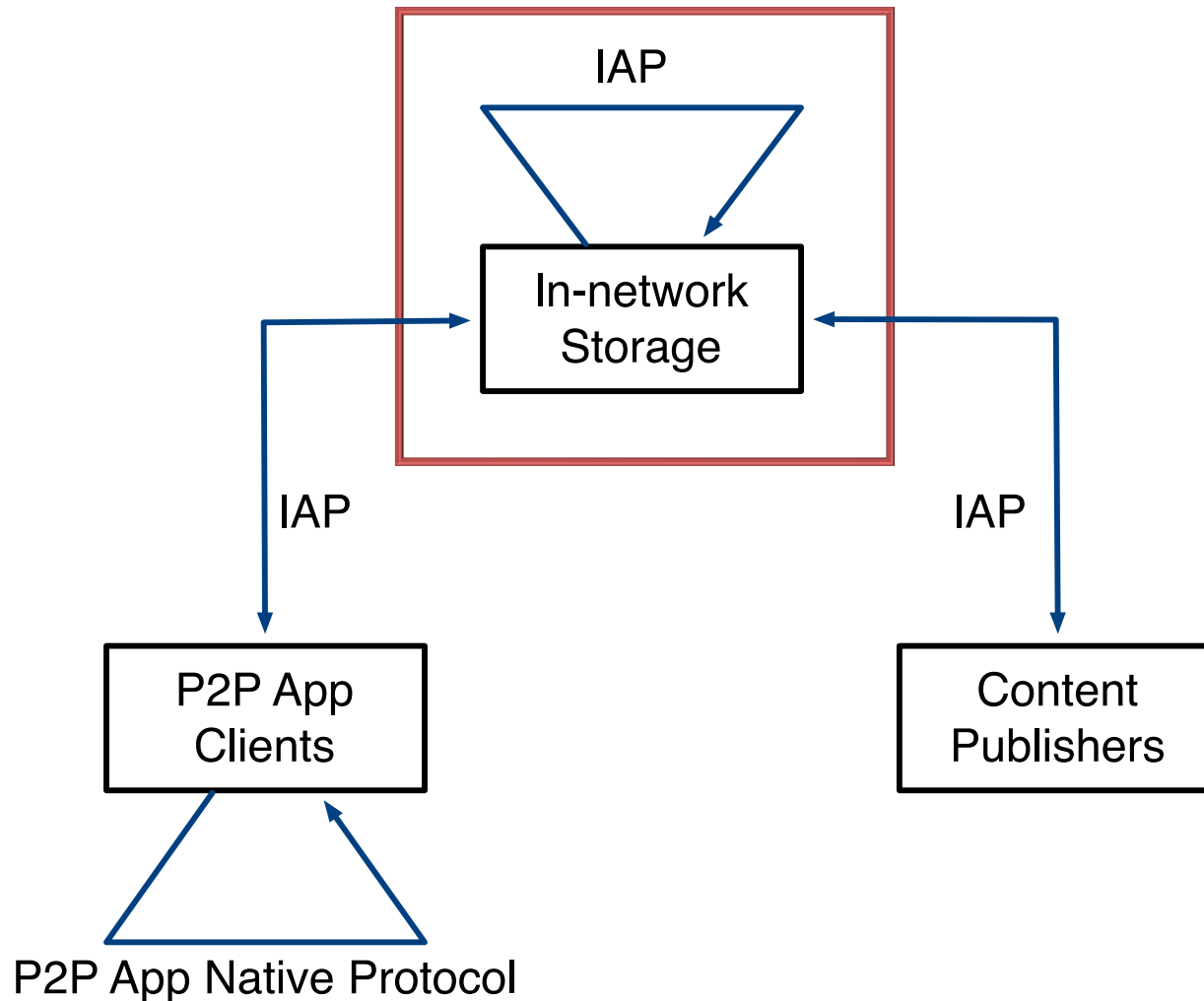
File Regeneration Protocol (FRP)

Regeneration Process

◆ Bandwidth measurement

- the newcomer and providers measure the available bandwidth between each other before the regeneration
- the newcomer collects all data of available bandwidth
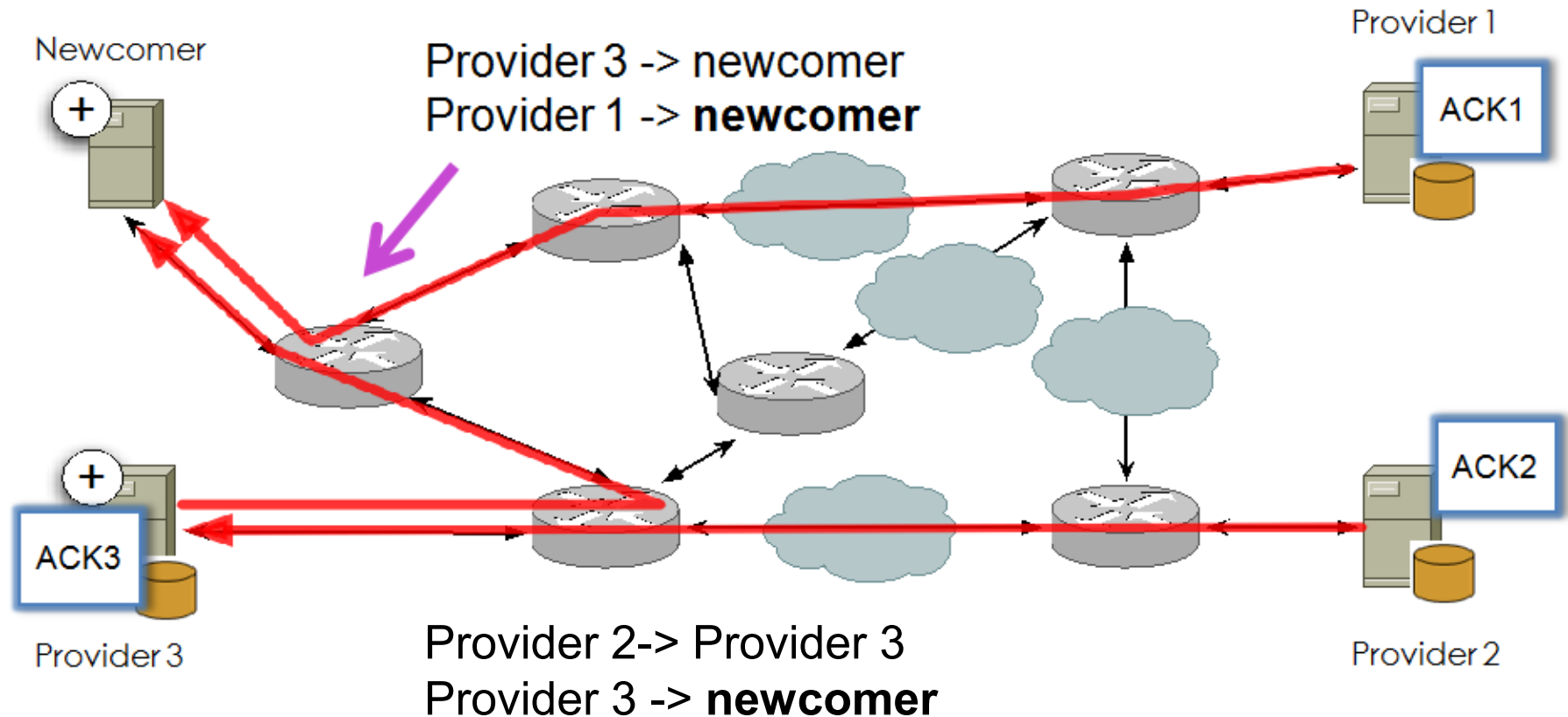
◆ Construction of the regeneration tree

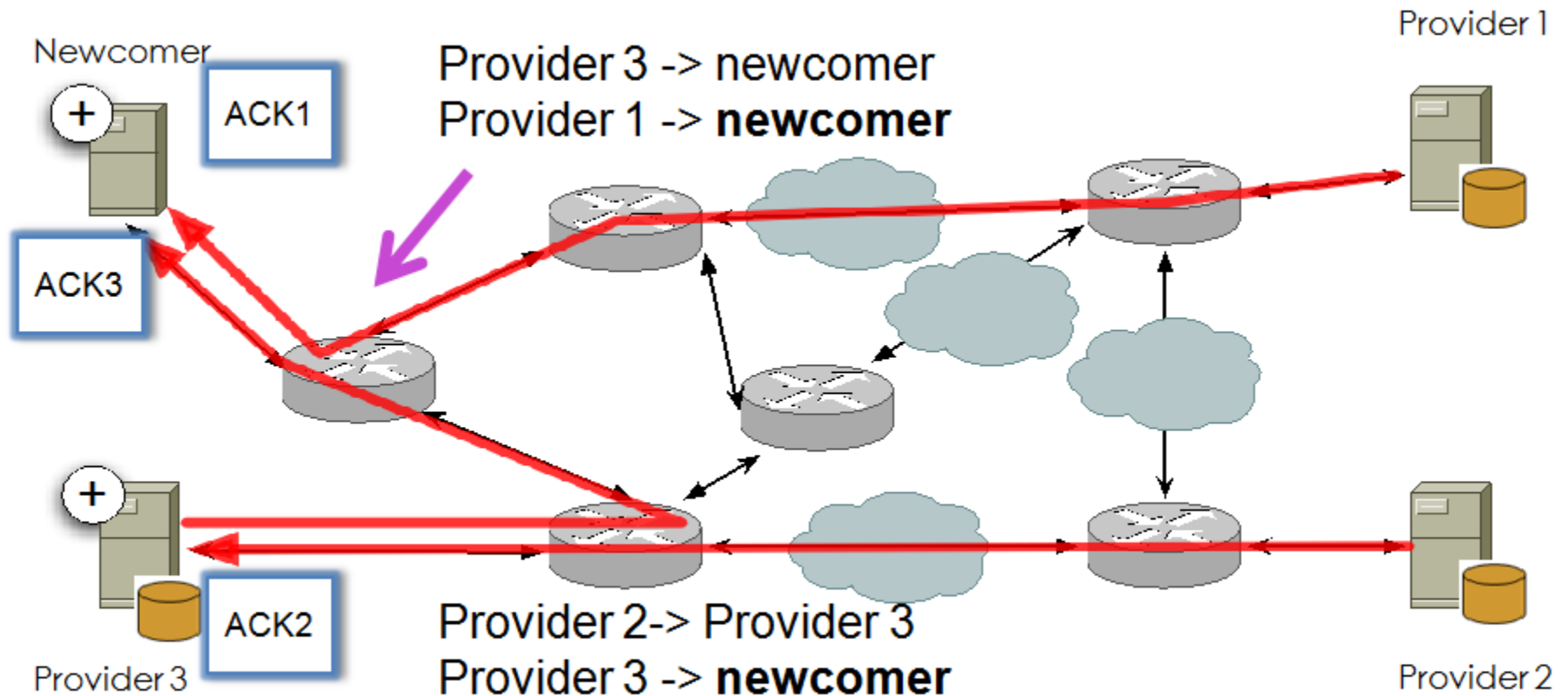- the newcomer constructs a maximum spanning tree

◆ Mapping

- application layer → network layer
- make supporting routers and providers know their duties
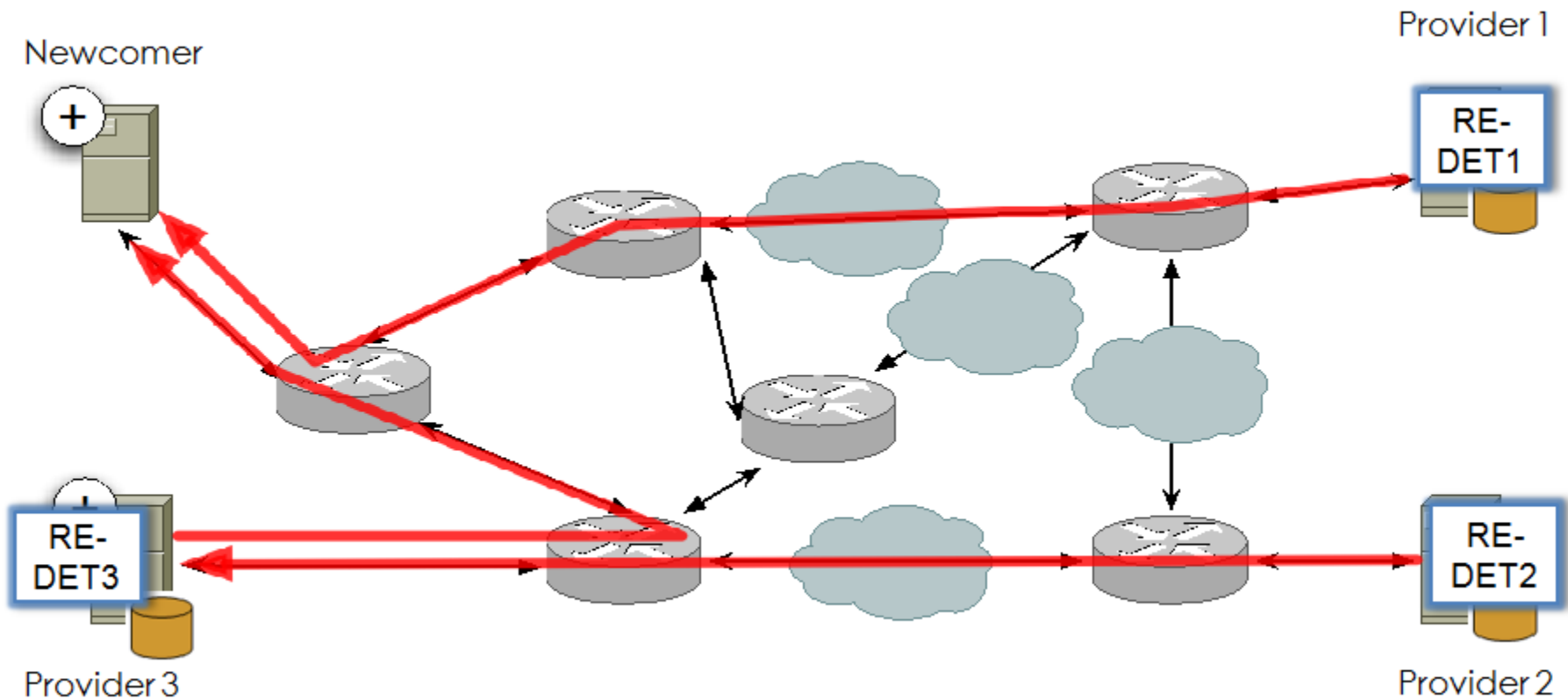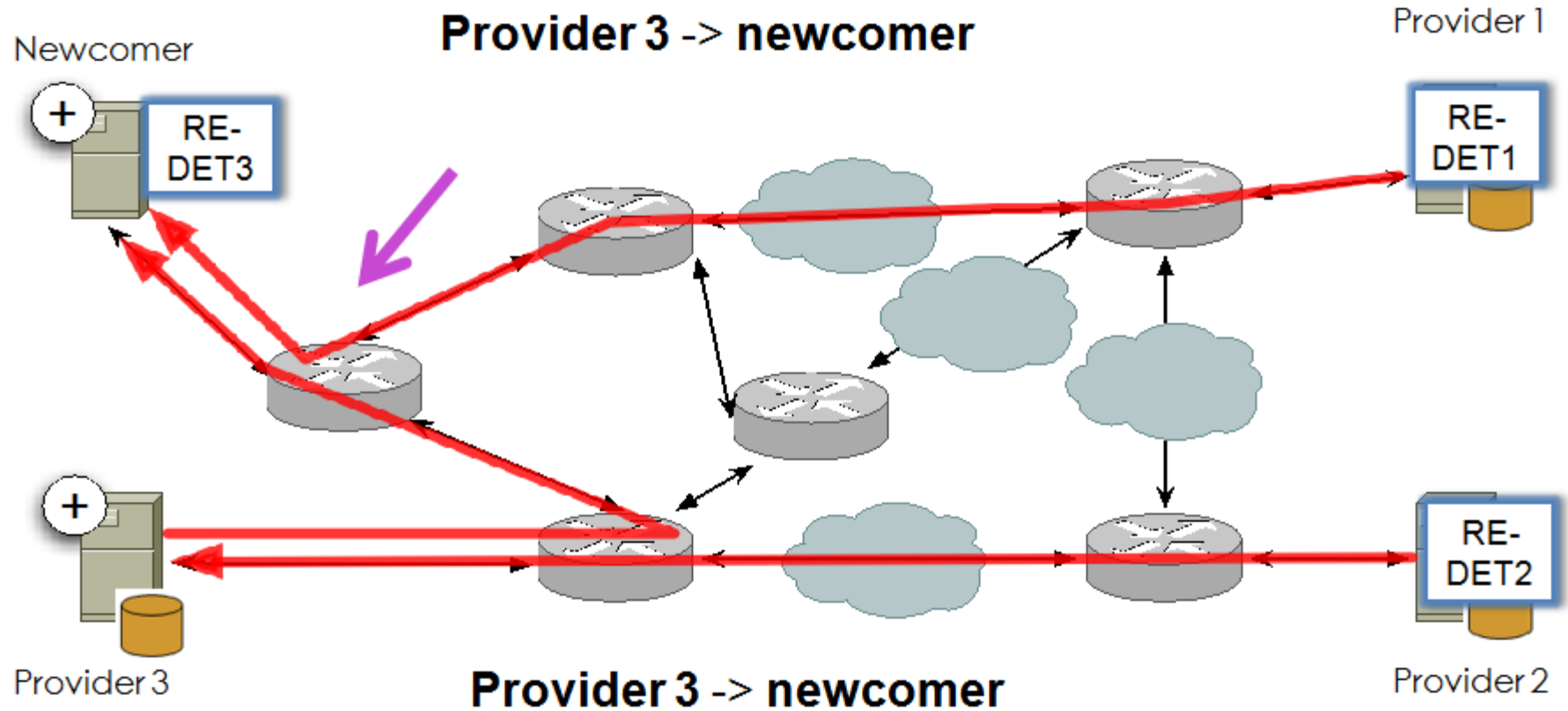
◆ Transmission

Mapping (1)

Provider 3 -> newcomer
Provider 1 -> **newcomer**

Provider 2-> Provider 3
Provider 3 -> **newcomer**

Mapping (1)

Mapping (2)

Mapping (2)

Provider 3 -> newcomer

Mapping (2)

Provider 3 -> **newcomer**

Newcomer

Provider 1

RE-DET3

RE-DET1

RE-DET2

Provider 3

Provider 2 -> **Provider 3**
Provider 3 -> **newcomer**

Provider 2

Mapping (2)

Provider 1 -> newcomer
Provider 3 -> **newcomer**

Provider 2 -> Provider 3
Provider 3 -> **newcomer**

Newcomer

RE-DET3

RE-DET1

RE-DET2

Provider 3

Provider 1
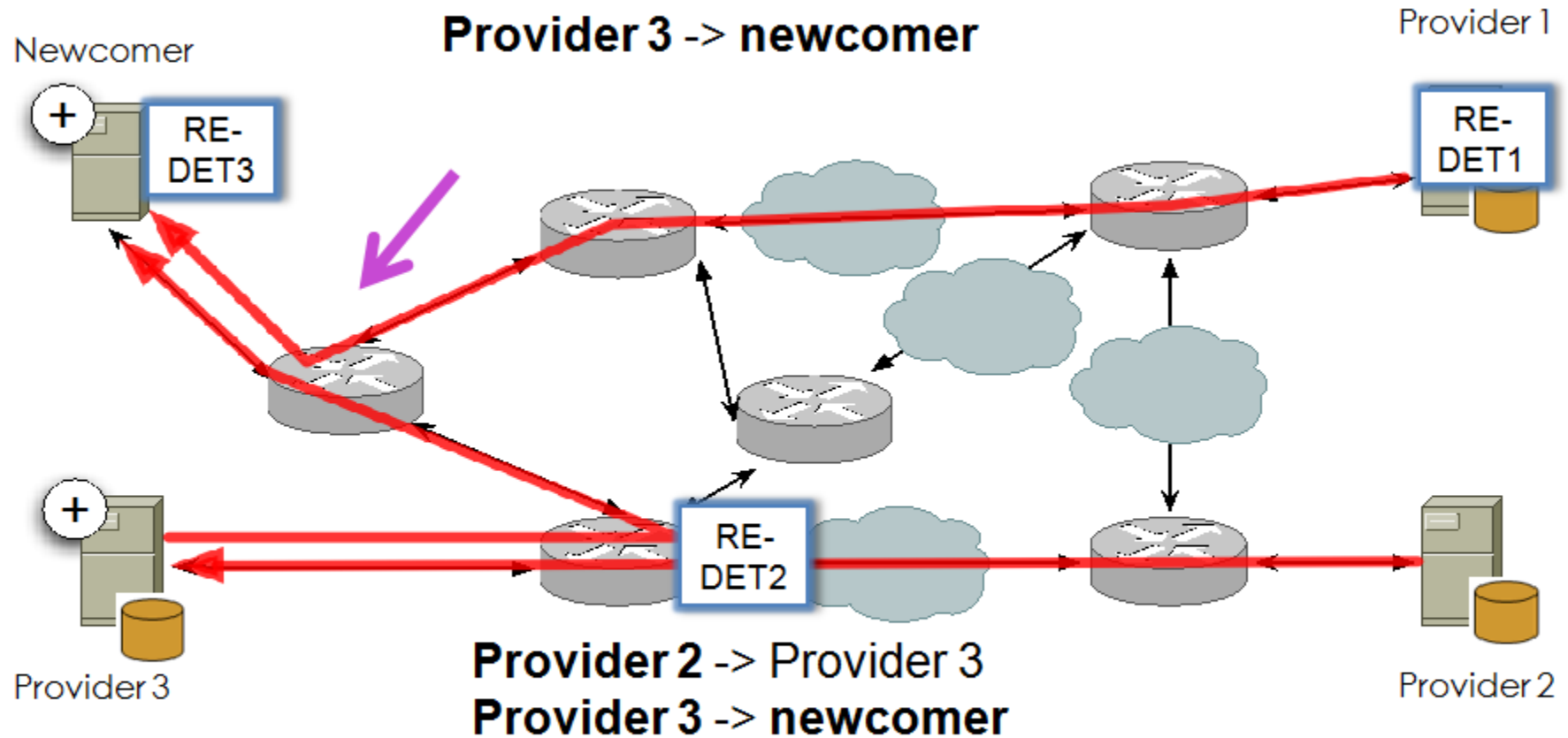
Provider 2
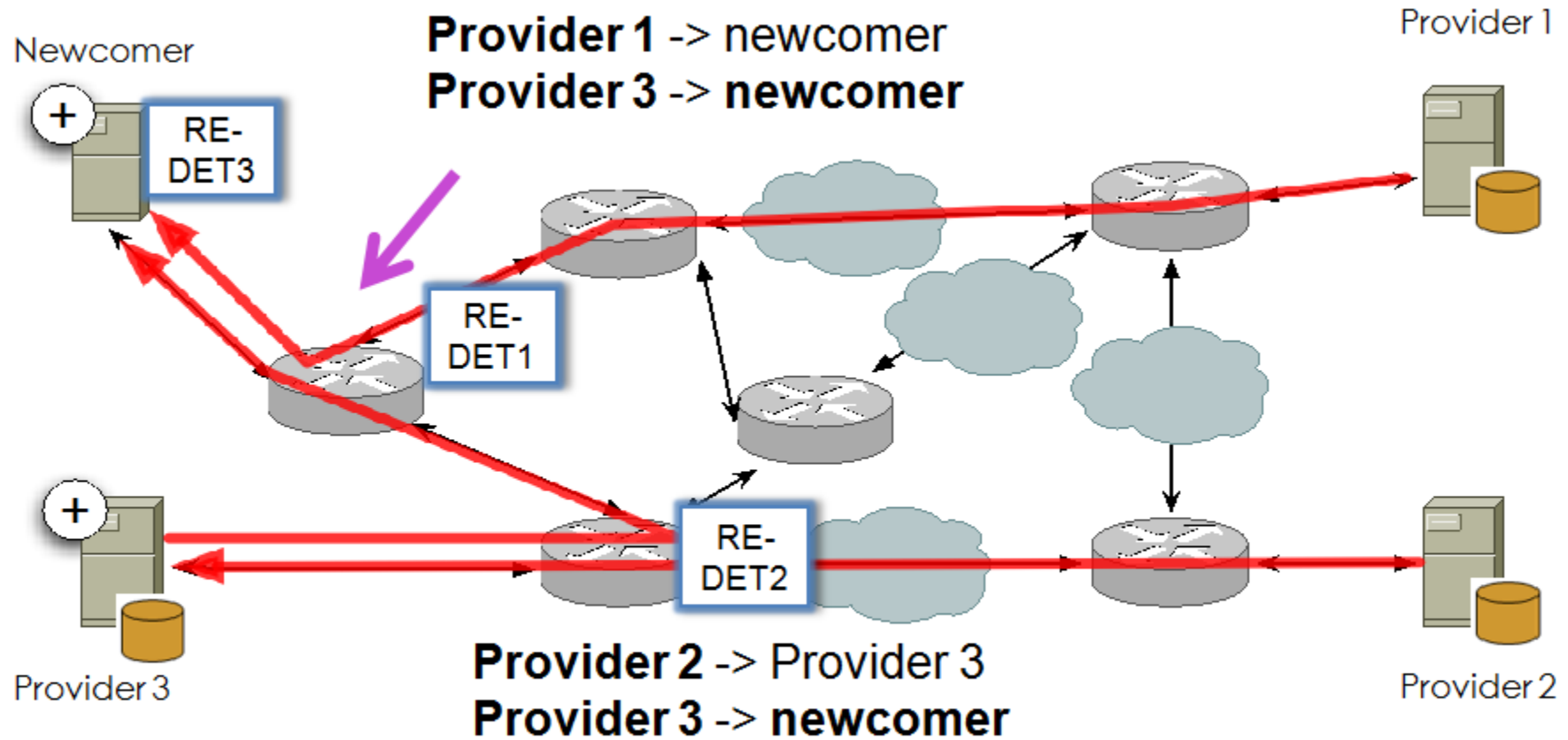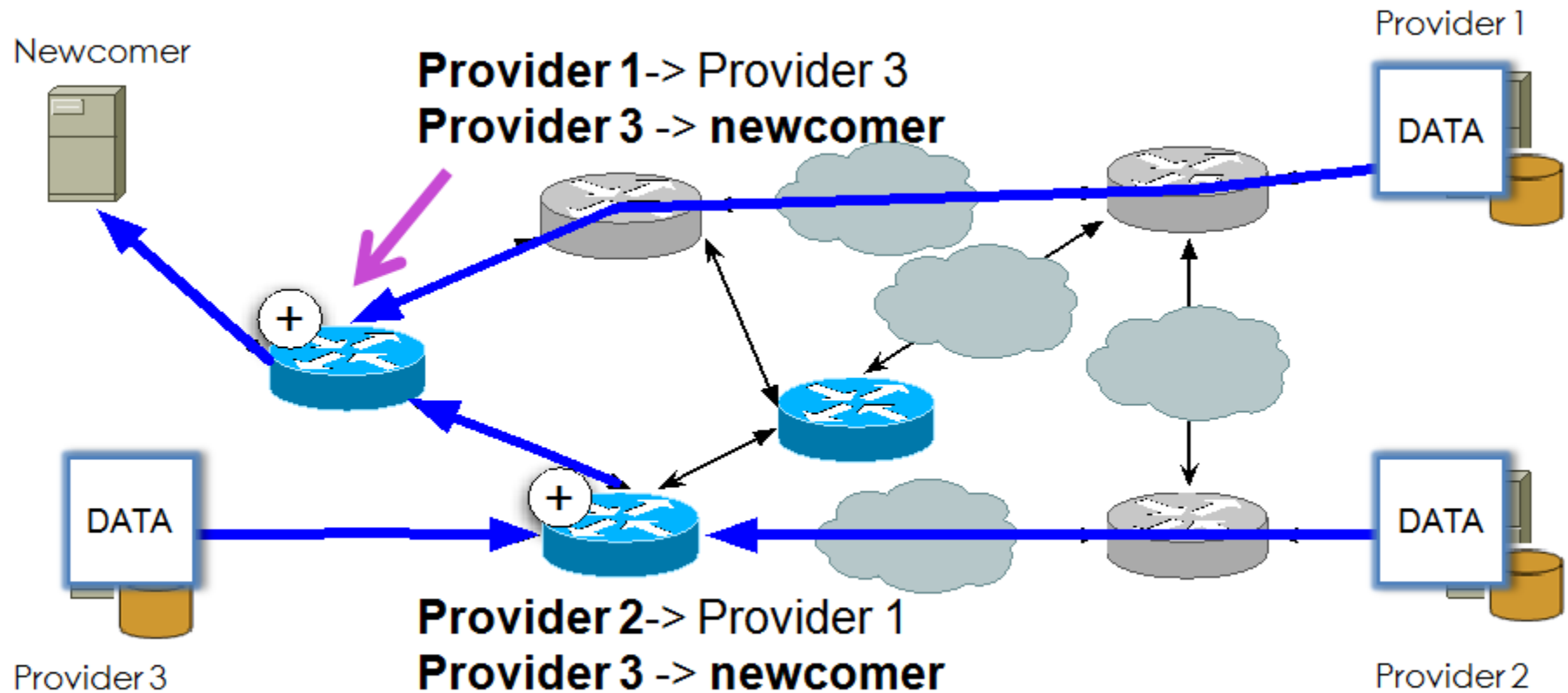
Transmission
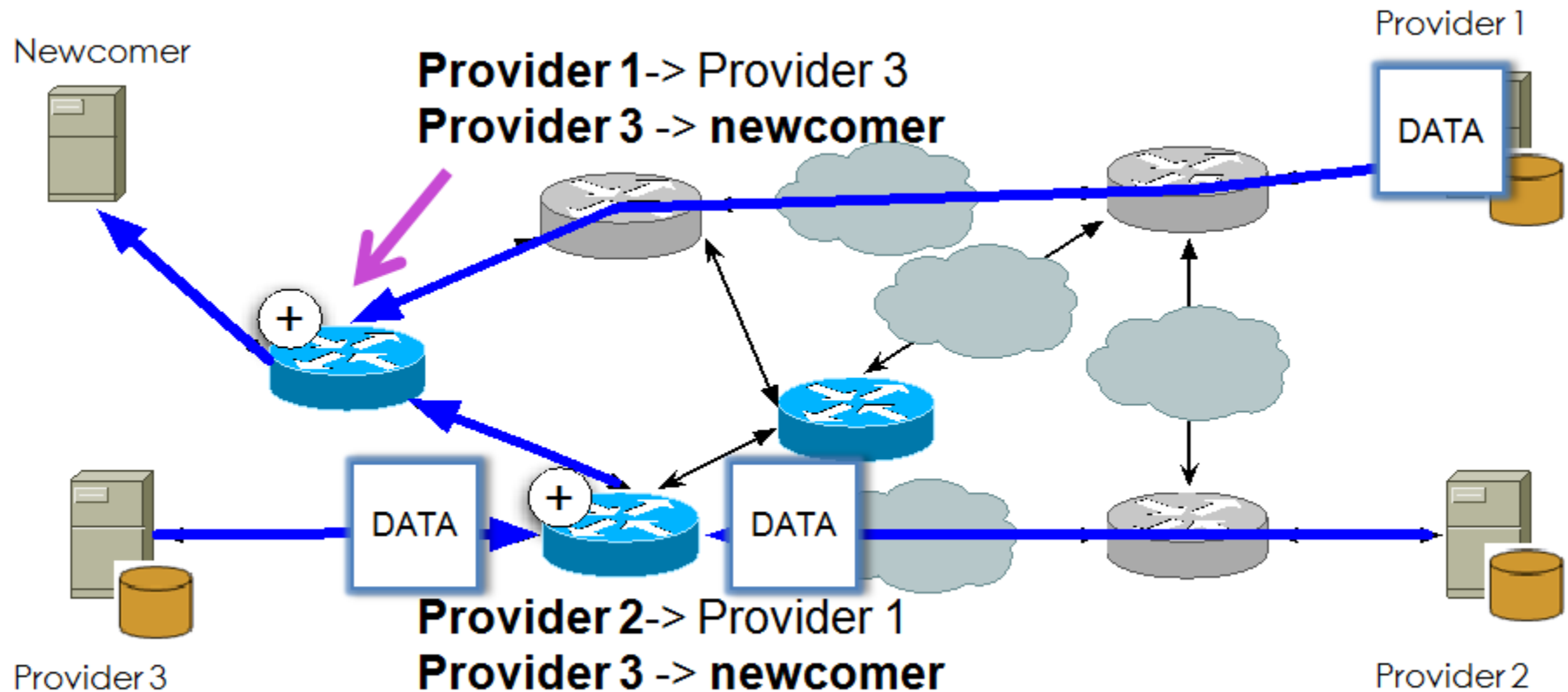
Transmission
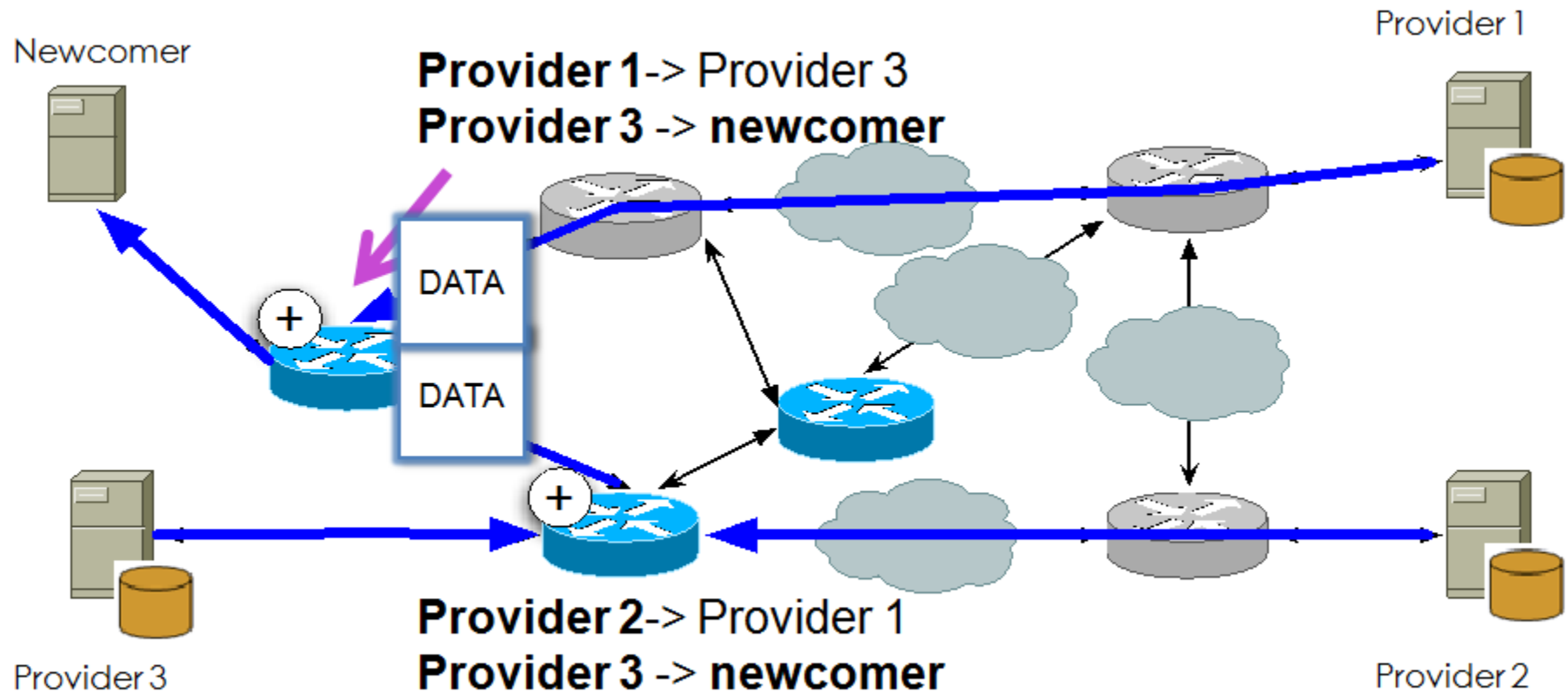
Transmission

Transmission

Experiment

```
+-----+          +-----+          +-----+          +-----+
|DI+NC|--60--| SR1 |--50--| SR4 |--80--| PR3 |
+-----+          +-----+          +-----+          +-----+
                    |      \            |
                    |40     \ 25        |20
                    |         \         |
+-----+          +-----+          +-----+          +-----+
| PR1 |--80--| SR2 |--50--| SR3 |--80--| PR2 |
+-----+          +-----+          +-----+          +-----+
```
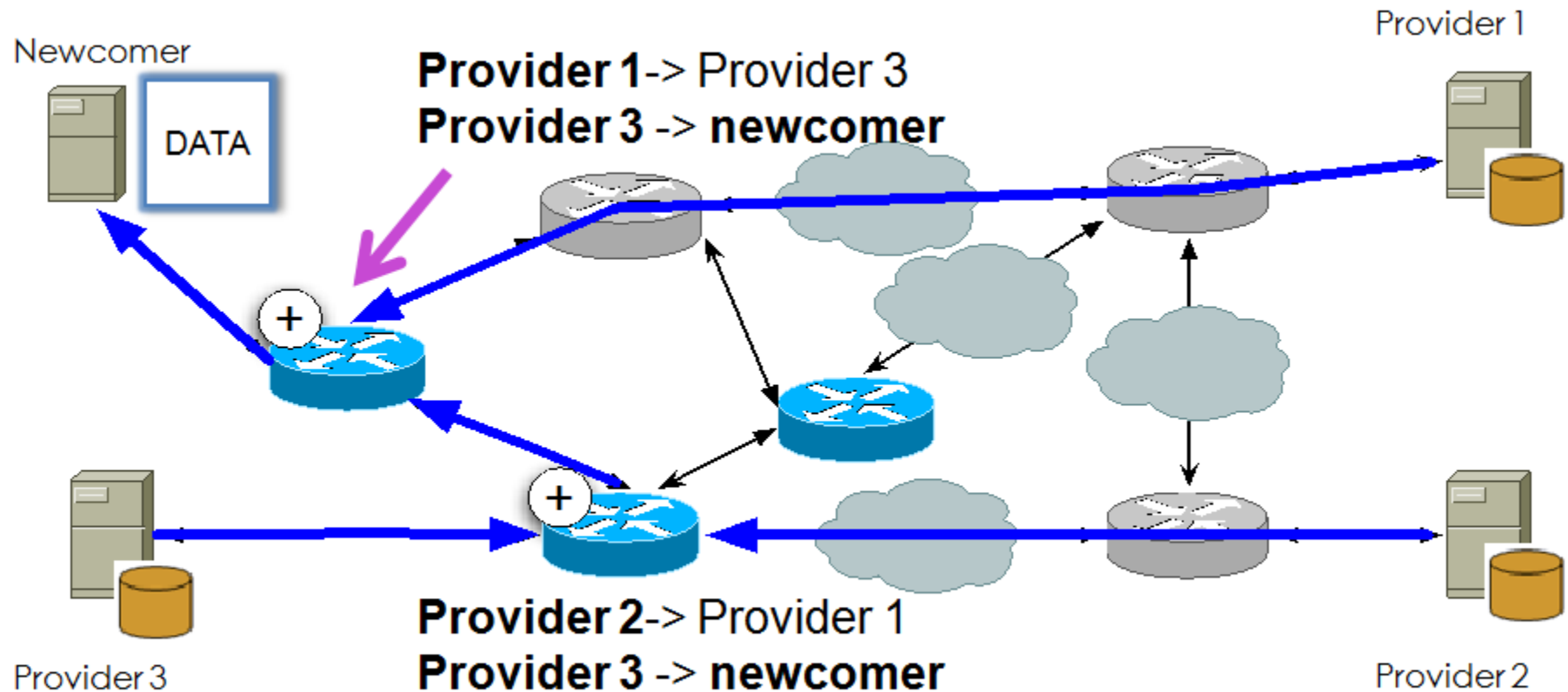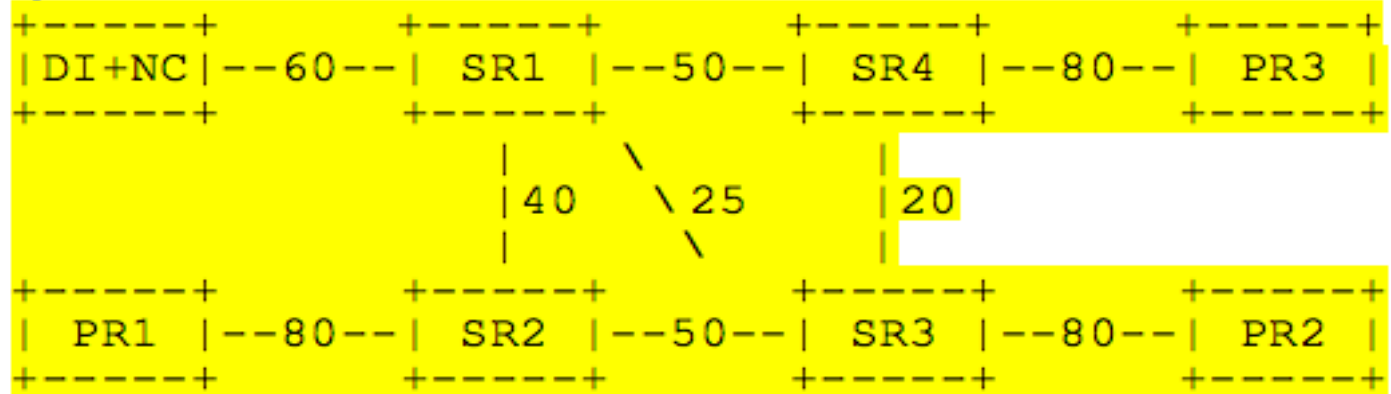
	Conventional regeneration	Router-supported regeneration
Traffic	58241047 bytes	45606648 bytes
Time	95.4 sec.	49.4 sec.

◆ Save traffic by 21.7%

- routers or peers send out less data after encoding

◆ Save time by 48.3%

- bypass links with low available bandwidth
- reduce traffic on some links

Conclusions

◆ Erasure codes provide high data integrity, but they may lead to inefficient regeneration processes.
  ⚬ traffic & time

◆ Routers can support the regeneration process such as to improve its efficiency.
  ⚬ encode data inside the network
  ⚬ bypass links with low available bandwidth

◆ File Regeneration Protocol (FRP)

◆ Supporting routers work efficiently in a transparent and decentralized way.

Thank you!

For more information:

http://sonic.fudan.edu.cn/junli/