

Understanding Route Redistribution

ICNP 2007
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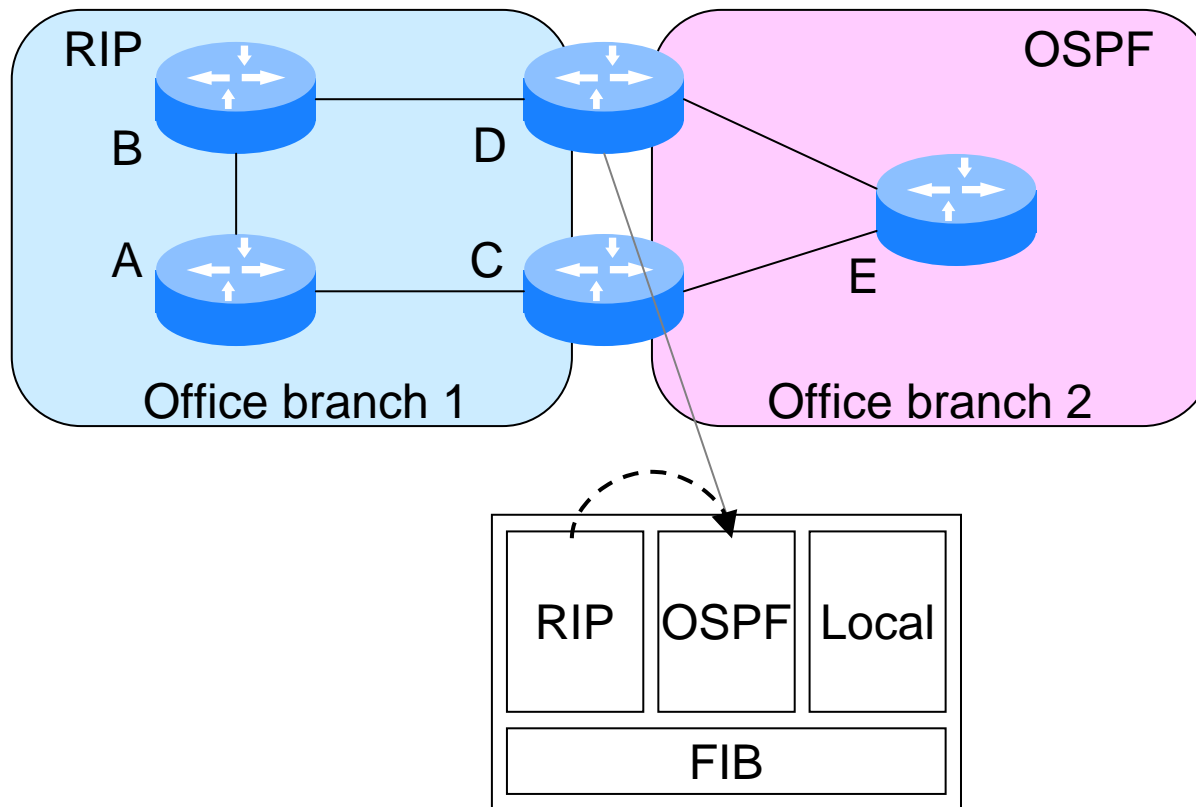
Franck Le, Geoffrey G. Xie, Hui Zhang

Internetwork and Routing

- Common view:
 - Intra-domain routing using OSPF, RIP
 - Inter-domain routing using BGP
- In reality, internetworking is much more complex
 - ISP networks:
 - BGP needs to distribute routes to OSPF and vice versa
 - Enterprise networks:
 - When BGP is not used, needs mechanism to distribute routes among OSPF, RIP, EIGRP domains
 - Also, needs to distribute routes among multiple OSPF domains

What is Route Re-Distribution (RR)?

By default, OSPF routers have no visibility of RIP routers



```
router ospf 27
 redistribute rip metric
 200 subnets route-map
 rip2ospf
 distance ospf external
 200
!
route-map rip2ospf permit
 100
 match ip address 100
 set tag 22
 set metric-type-1
```

How Does RR Compare to BGP?

- In many scenarios, RR, not BGP, is used to interconnect network domains,
- Even when BGP is used, RR is required to connect BGP and IGP
- RR can implement policy, like BGP
- Unlike BGP, RR is NOT a protocol
 - RR is just a configuration mechanism, used separately at each router

RR is more commonly used than BGP, but much less understood, and much more error-prone

Problem Statements

- Given an internetwork with RR configurations, what are the loop-free and convergence properties?
- What are the guidelines of using RR if one wants to have loop-free and convergent internetwork?

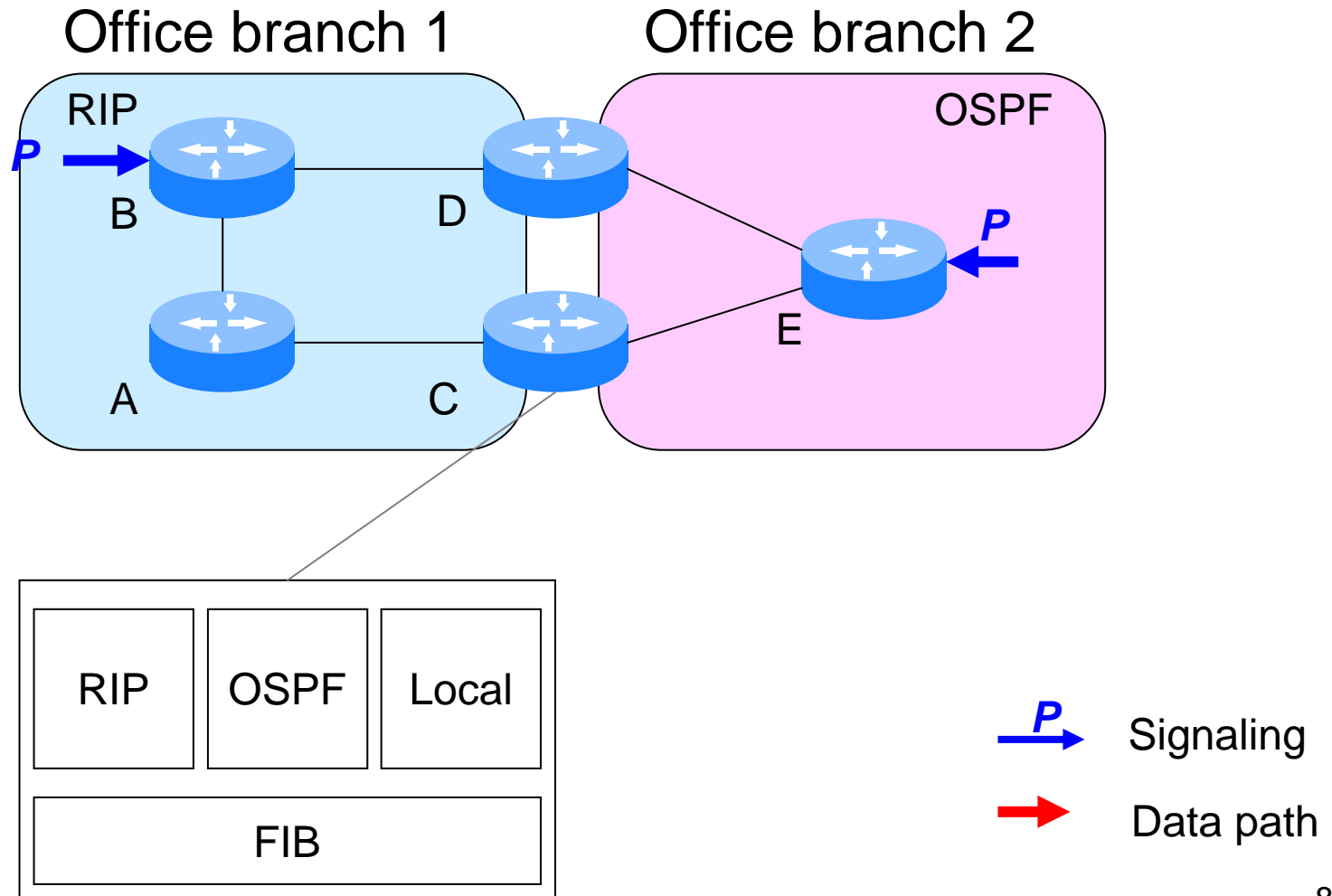
Synthesis of the Paper

- Model that reasons about the loop-free and convergence properties
- Sufficient condition to guarantee loop-free and convergence properties

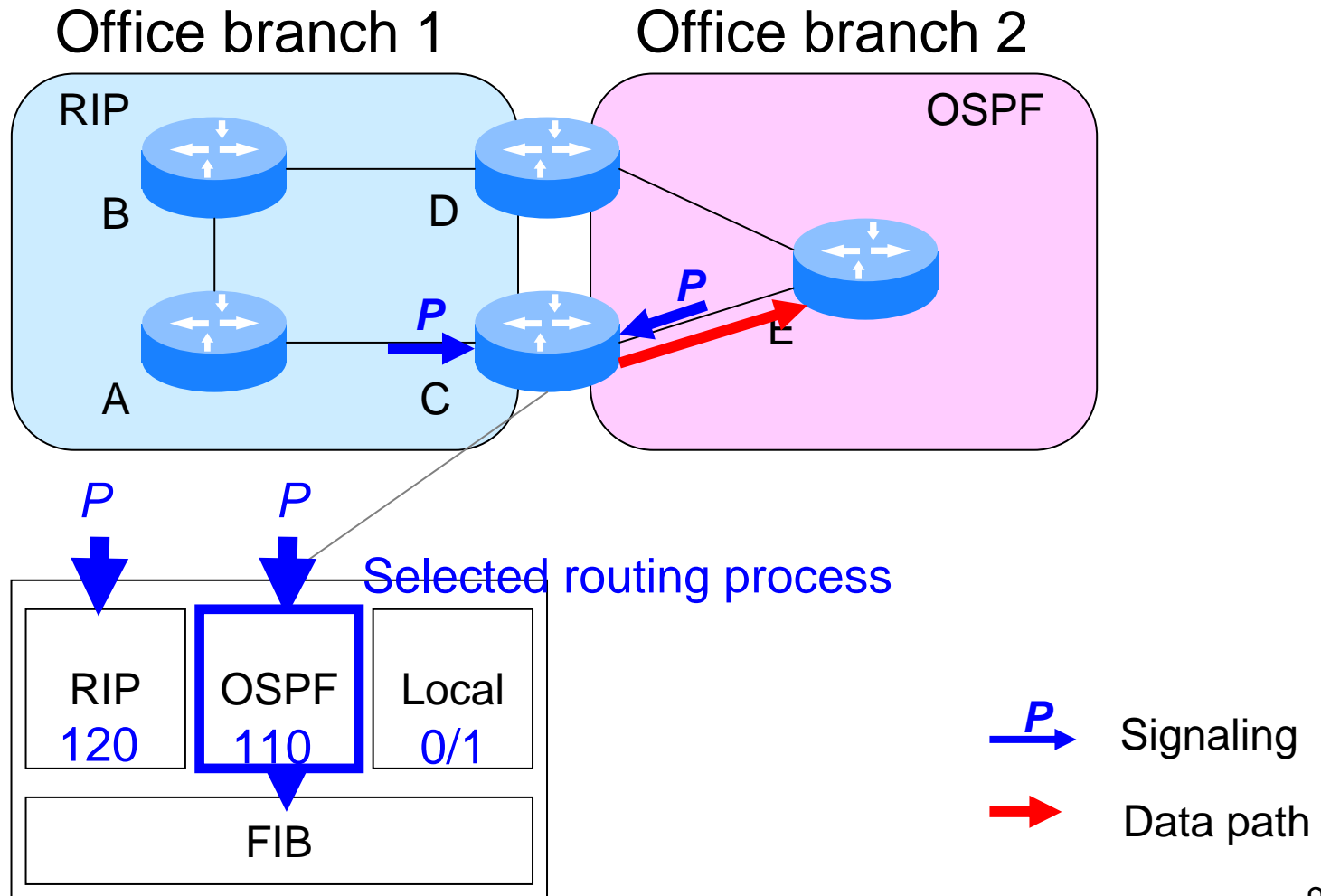
Outline

1. Introduction to Route Redistribution (RR)
2. Illustration of routing anomalies
3. A Model for RR
4. Sufficient condition for loop-free and convergent RR

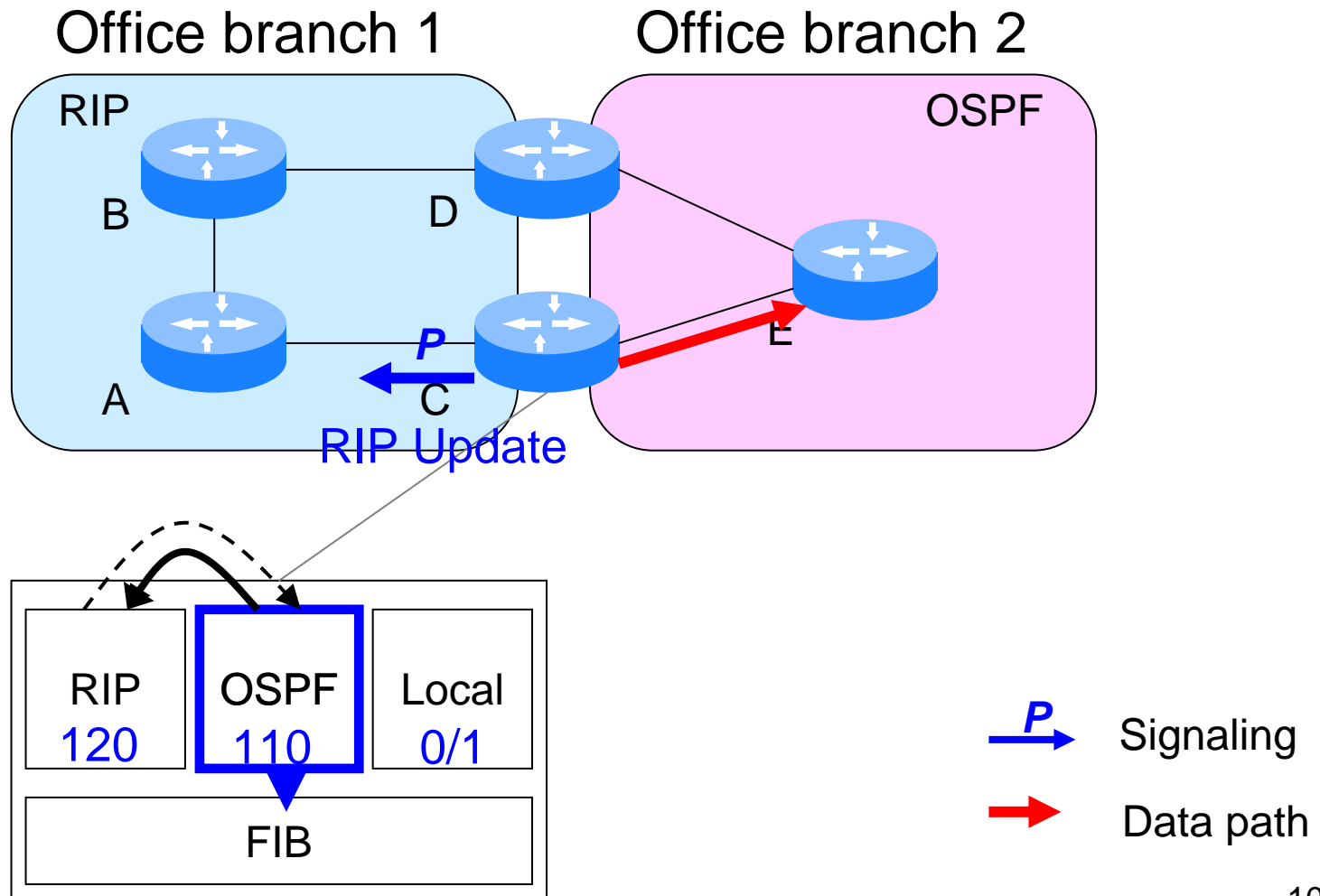
Route Selection Process



Route Selection Process



Route Redistribution Process



Outline

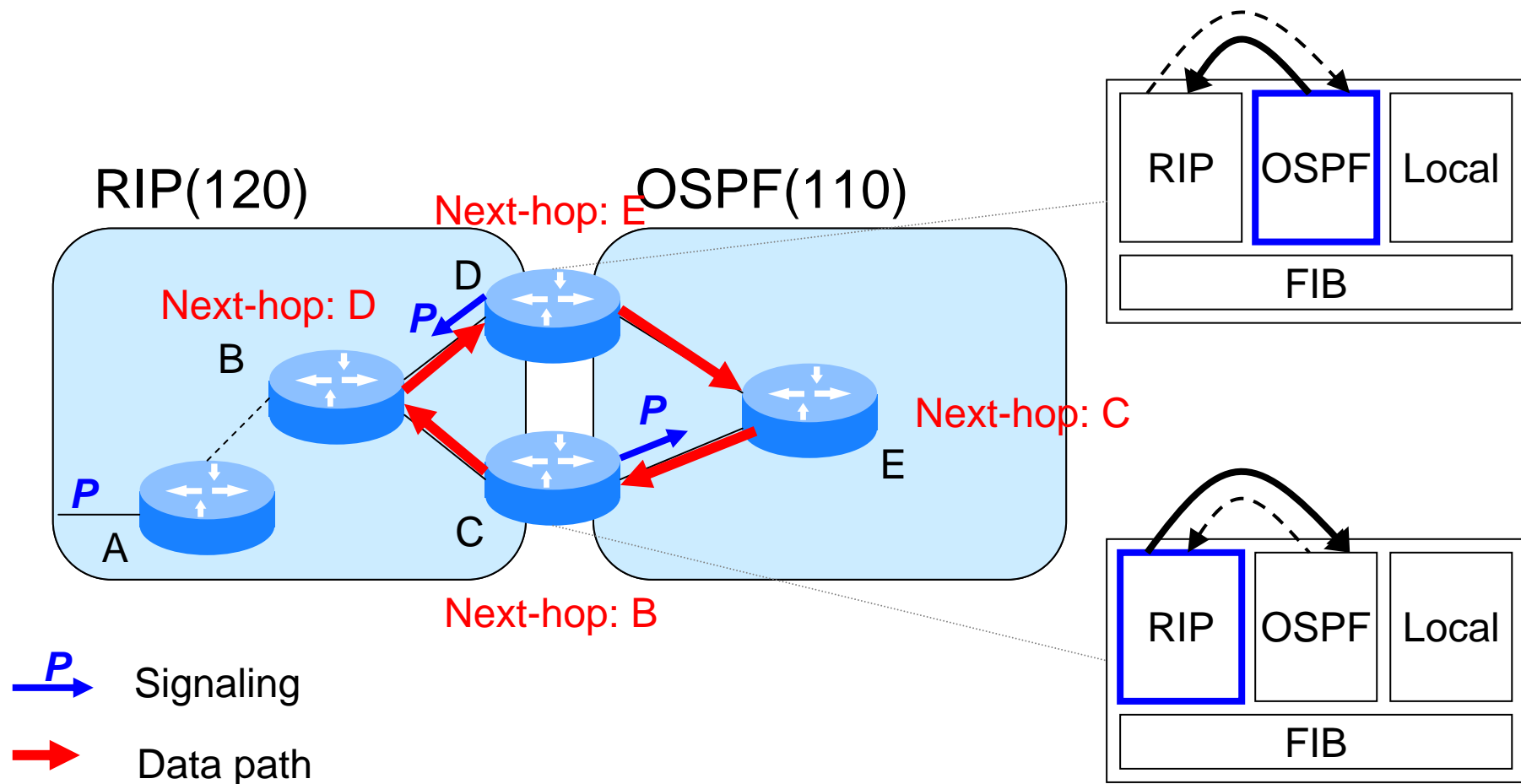
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Instabilities

- Range and degree of instability are, in fact, more extensive than those in BGP
 - Possible formation of forwarding loops
 - Absence of dispute wheels¹ not sufficient to guarantee oscillations-free configurations
- No general guideline to configure RR

¹ T. Griffin, F. B. Shepherd, and G. T. Wilfong. The Stable Paths Problem and Interdomain Routing. IEEE/ACM Trans. Netw., 2002.

Formation of Routing Loops



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- 3. A Model for RR**
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Challenges

- Too many network elements
 - Hundreds or thousands of routers
- Different router processing order
 - Routers may process signaling messages in different order (message delay, router load)
 - Different order can result in different outcome

Solutions

- Too many network elements
 - Abstractions: routing instances
 - Logics: route selection, RR, network-wide RR
- Different router processing order
 - Activation sequence¹

¹ L. Gao and J. Rexford, Stable Internet Routing Without Global Coordination, in *Proc. ACM SIGMETRICS*, 2000

A Model for RR

- Abstracts the dynamic exchange of routing information for a prefix P
- Allows to predict paths

Route Propagation Graph

- Routing instance
- Originating routing instance
- Configured redistribution
- Actual redistribution
- Route vs. no route
- Variables: CL , S

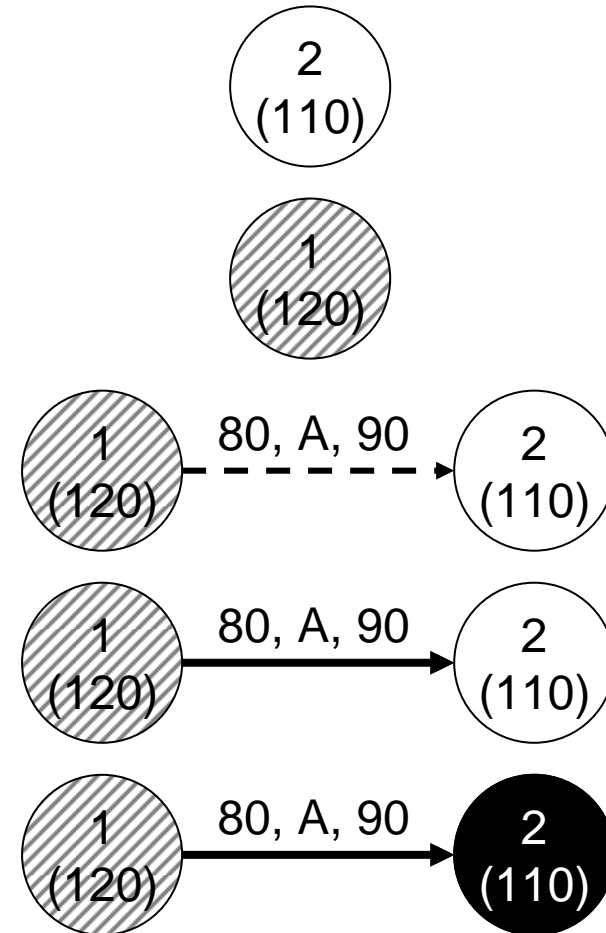


Illustration of Model

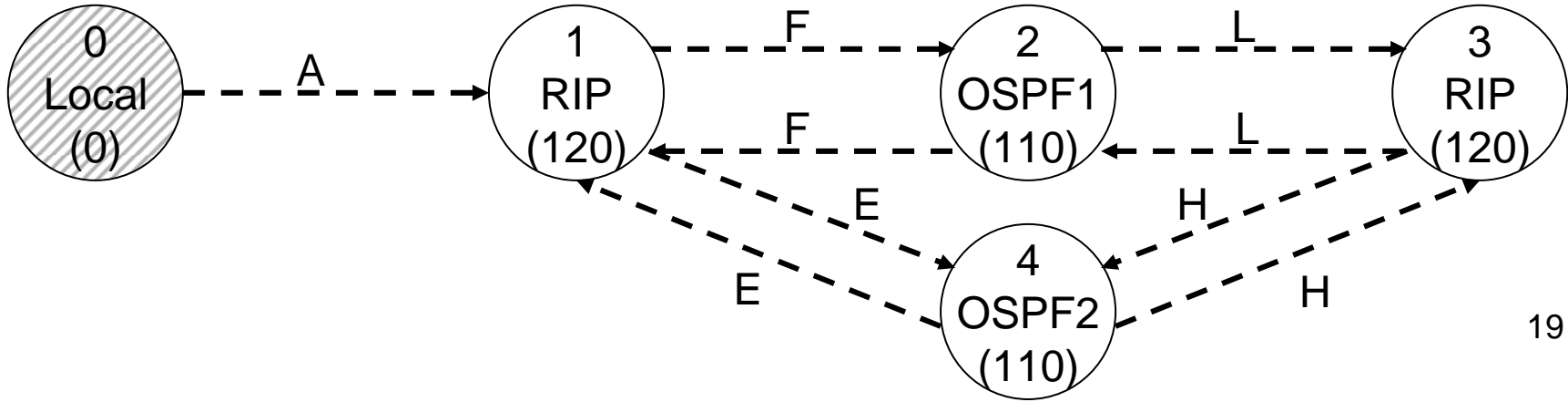
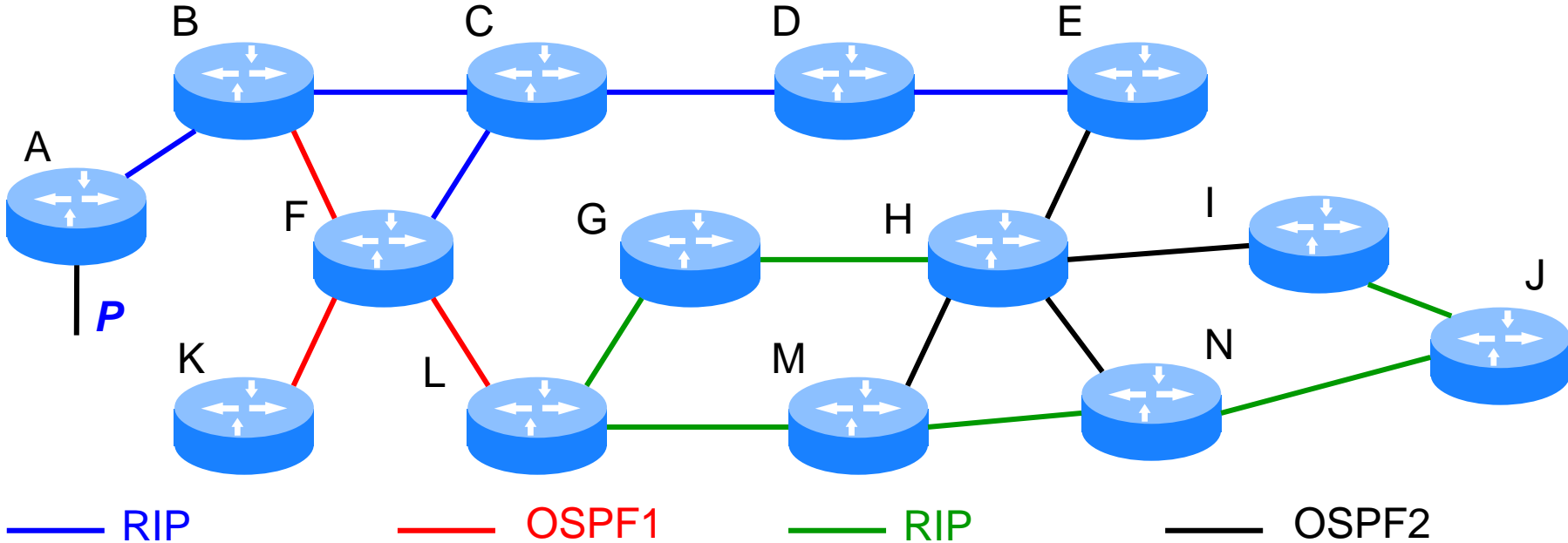
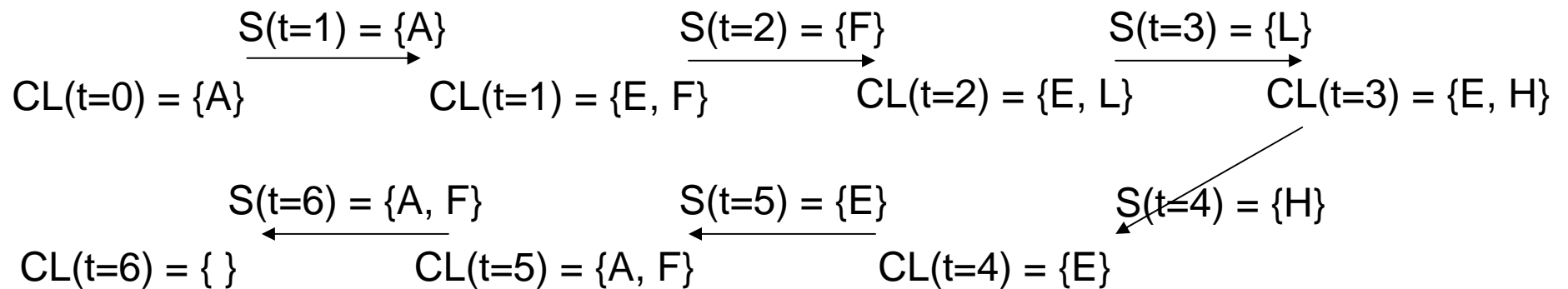
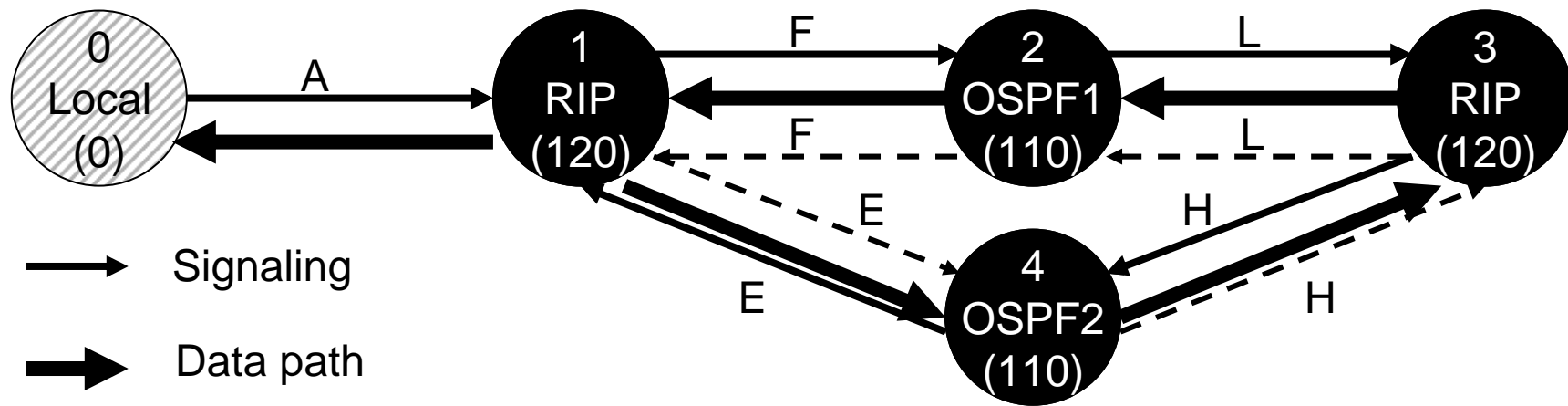


Illustration of Model Sequence 1



Route Redistribution Configuration - Cycle Detection (RRC-CD) Problem

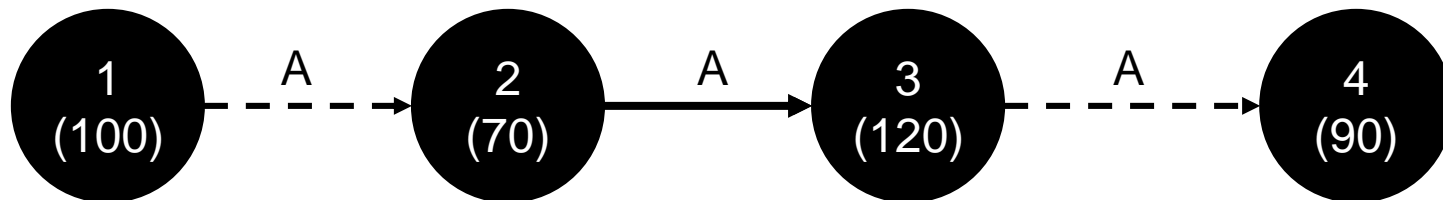
- Given a RR configuration, determining whether there is an activation sequence such that the redistributions converge to state including a cycle of active redistributions is NP-hard

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4. **Sufficient condition for loop-free and convergent RR**

Sufficient condition for safety

- Pruning of Route Propagation Graph
 - For each redistributing router, only conserve redistributions from the routing processes with lowest administrative distances
- Rationale
 - Focus on preferred redistributions



Sufficient condition

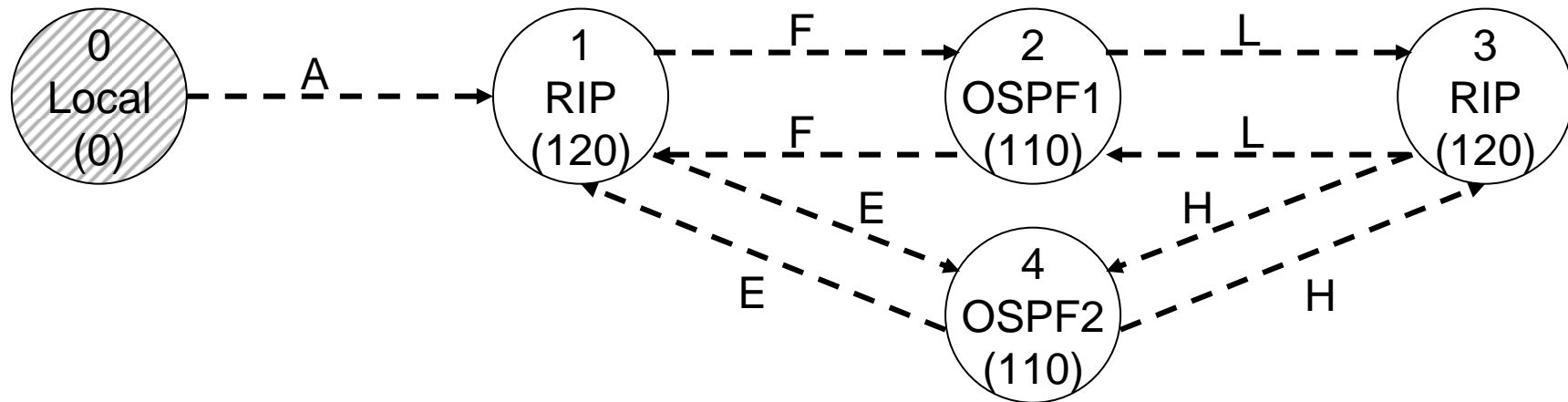
If resulting graph satisfies

1. Every redistributing router redistributes from a single routing instance (*predictable outcome*)
2. For all vertice, there is a redistribution path from a originating vertex (*active redistribution*)
3. The graph is acyclic (*no cycle*)

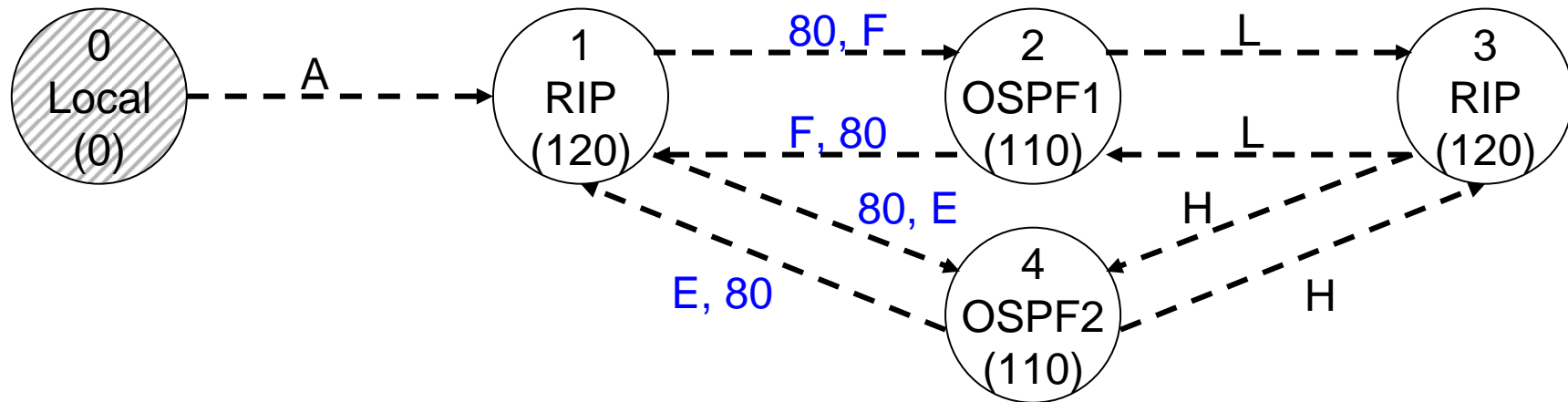
Then, the redistributions converge to an acyclic routing state

- No route oscillations
- No forwarding loops

Application of Sufficient Condition

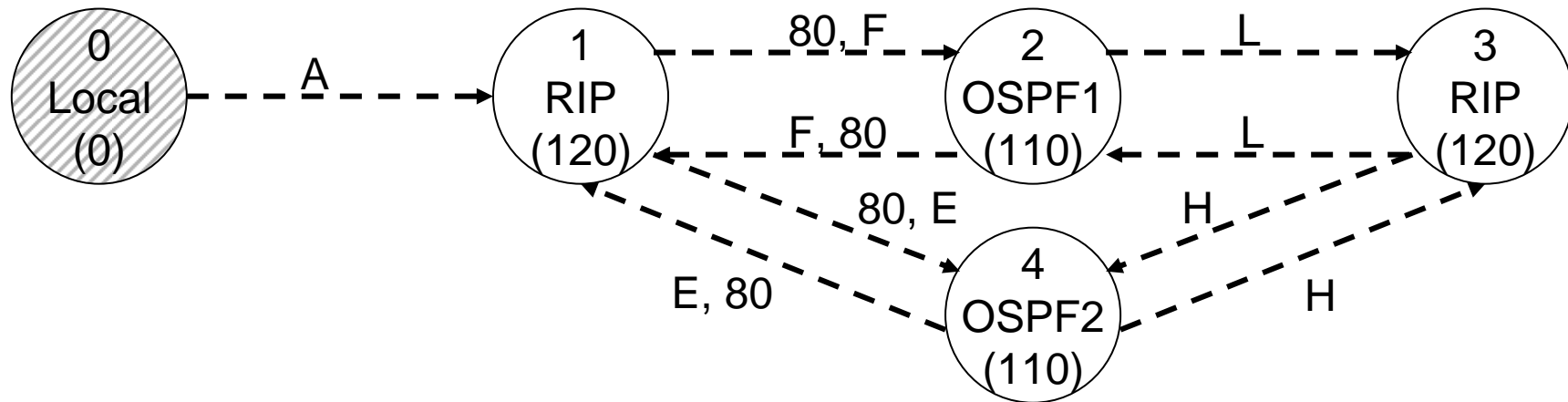


Application of Sufficient Condition



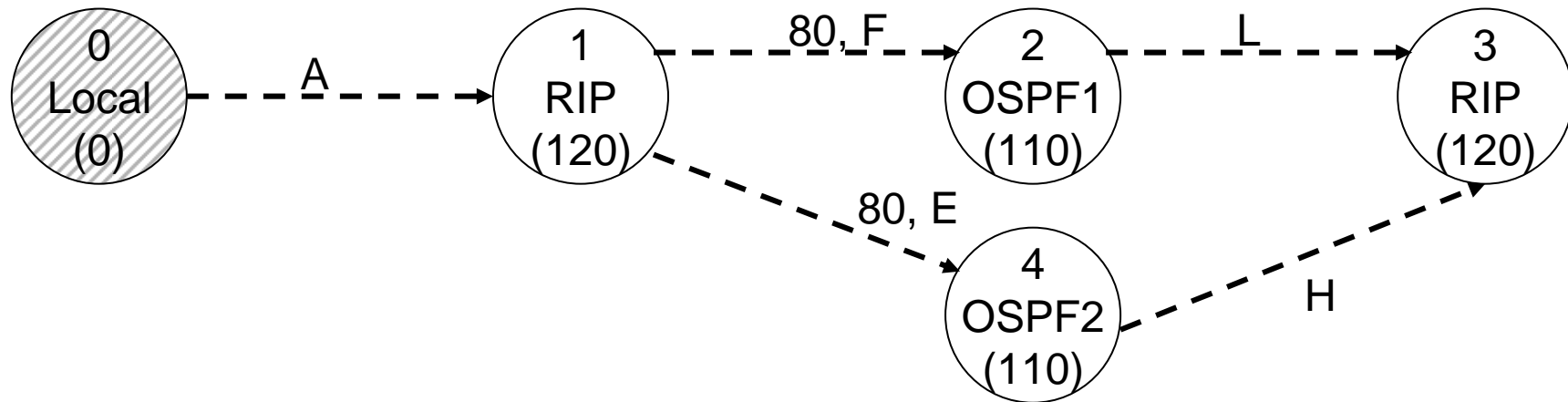
Modifications

Application of Sufficient Condition



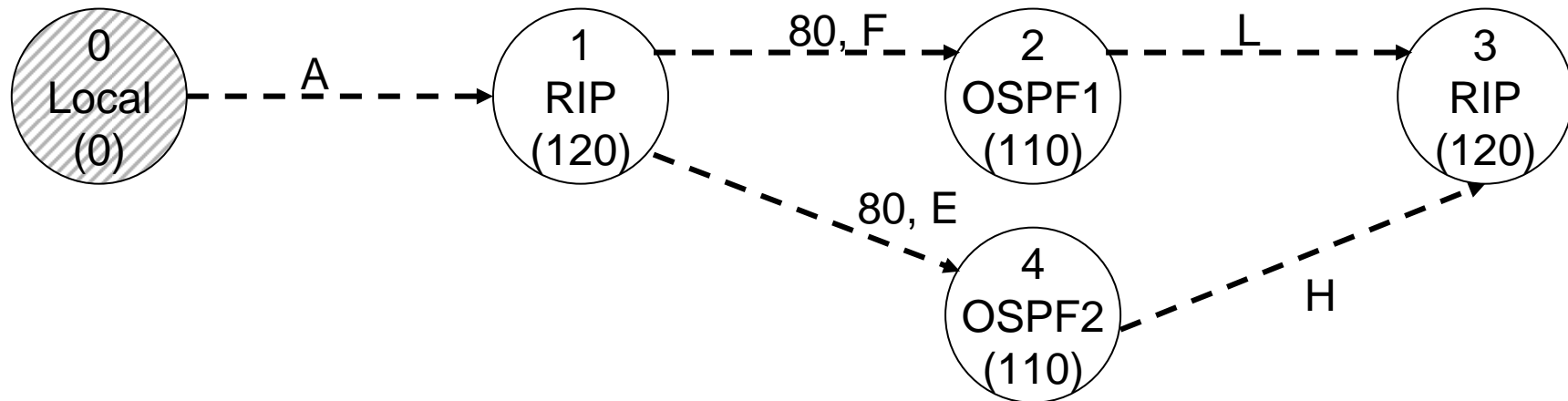
Pruning

Application of Sufficient Condition



Pruning

Application of Sufficient Condition



1. Every redistributing router is redistributing from a single routing instance.
2. For all vertices, there is a redistribution path from an originating vertex.
3. The graph is acyclic.

Summary

- Internetwork is far more complex with RR than the conceptual model of BGP/OSPF
- RR serves a fundamental need, but is not well-understood or even well-designed
- First formal study route-free and convergence properties of RR internetwork
 - Model
 - Sufficient condition

Future Work

- If one were to re-design the RR, what should be the solution that supports all the RR applications but avoid the pitfalls?