Leveraging In-Network Application Awareness

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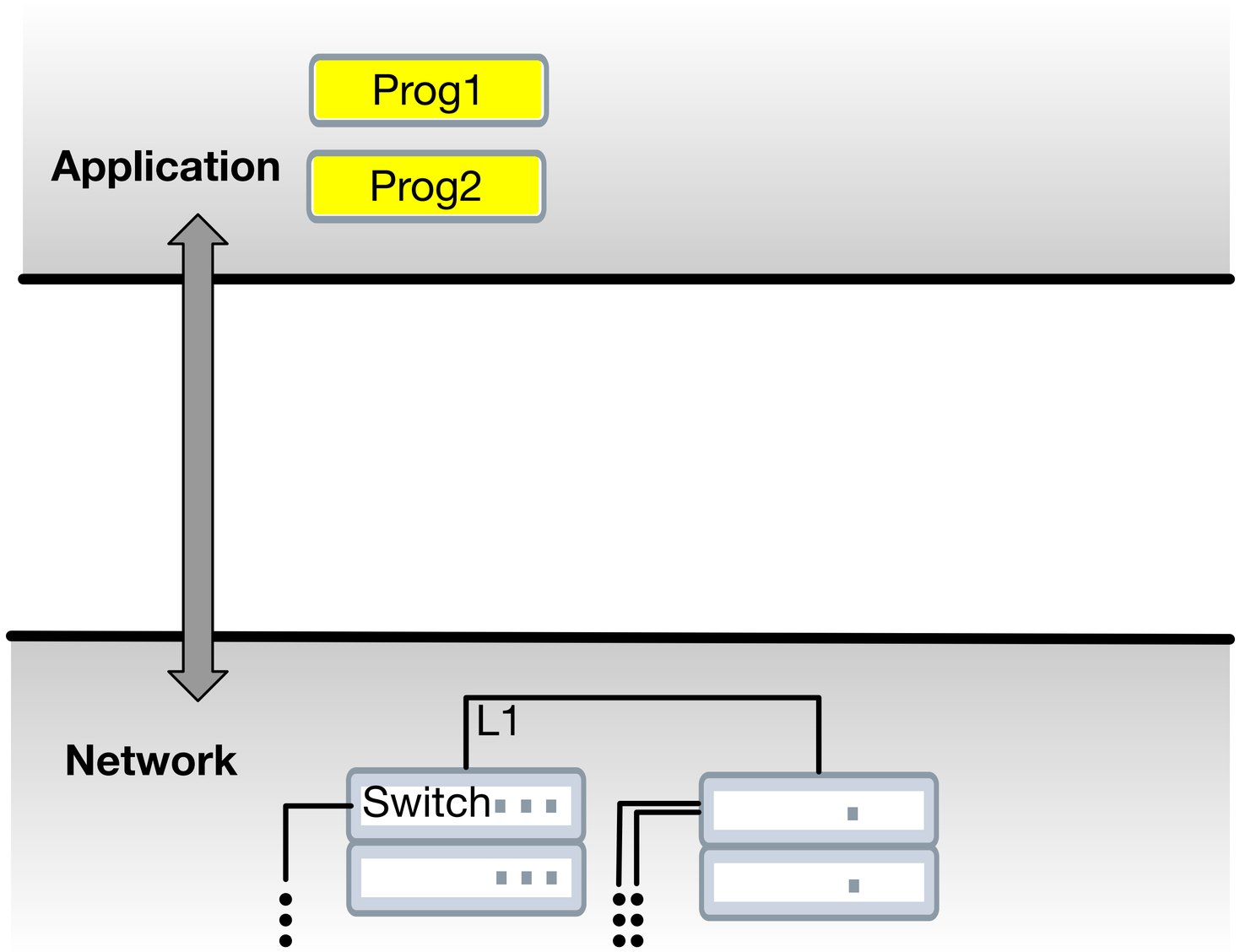
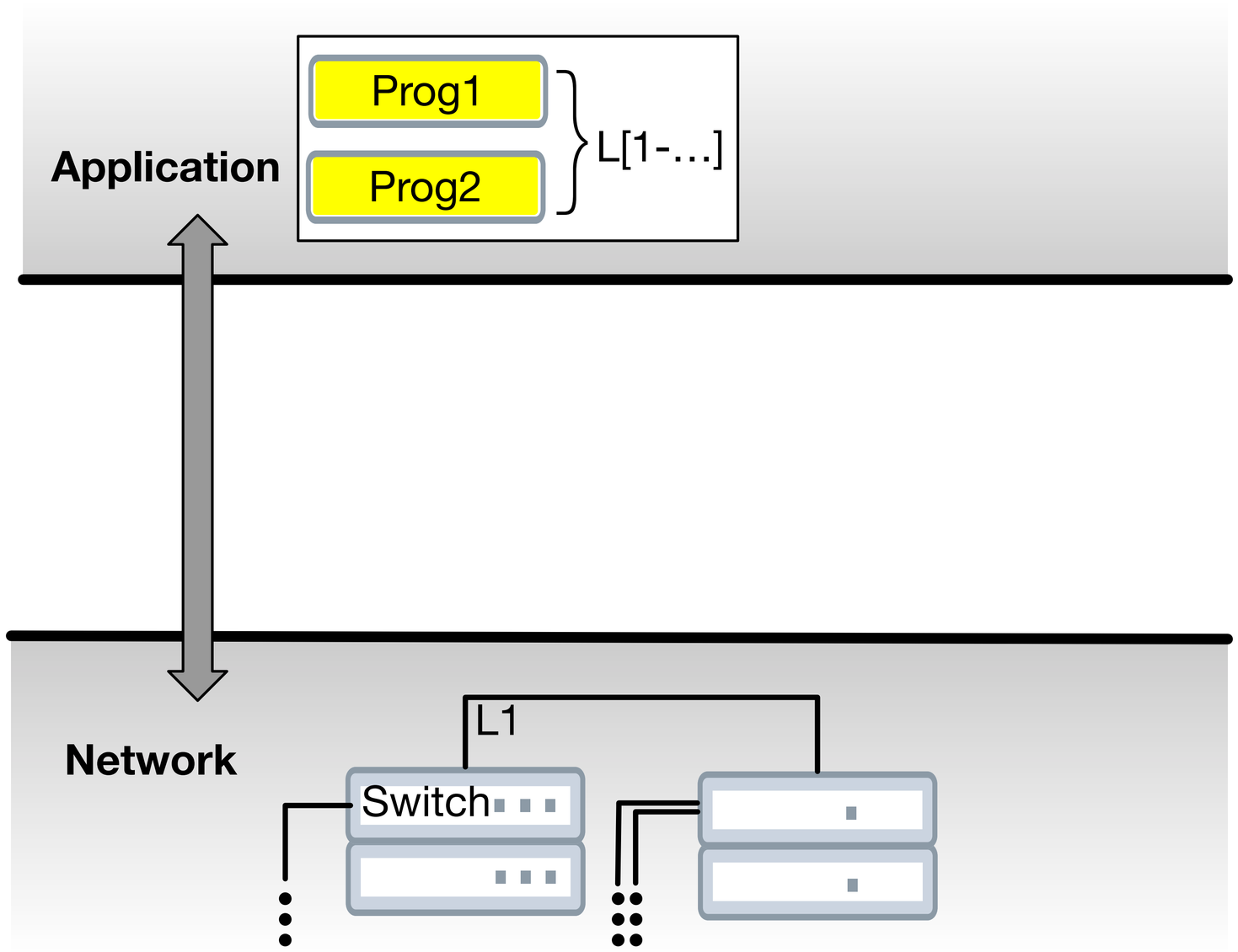
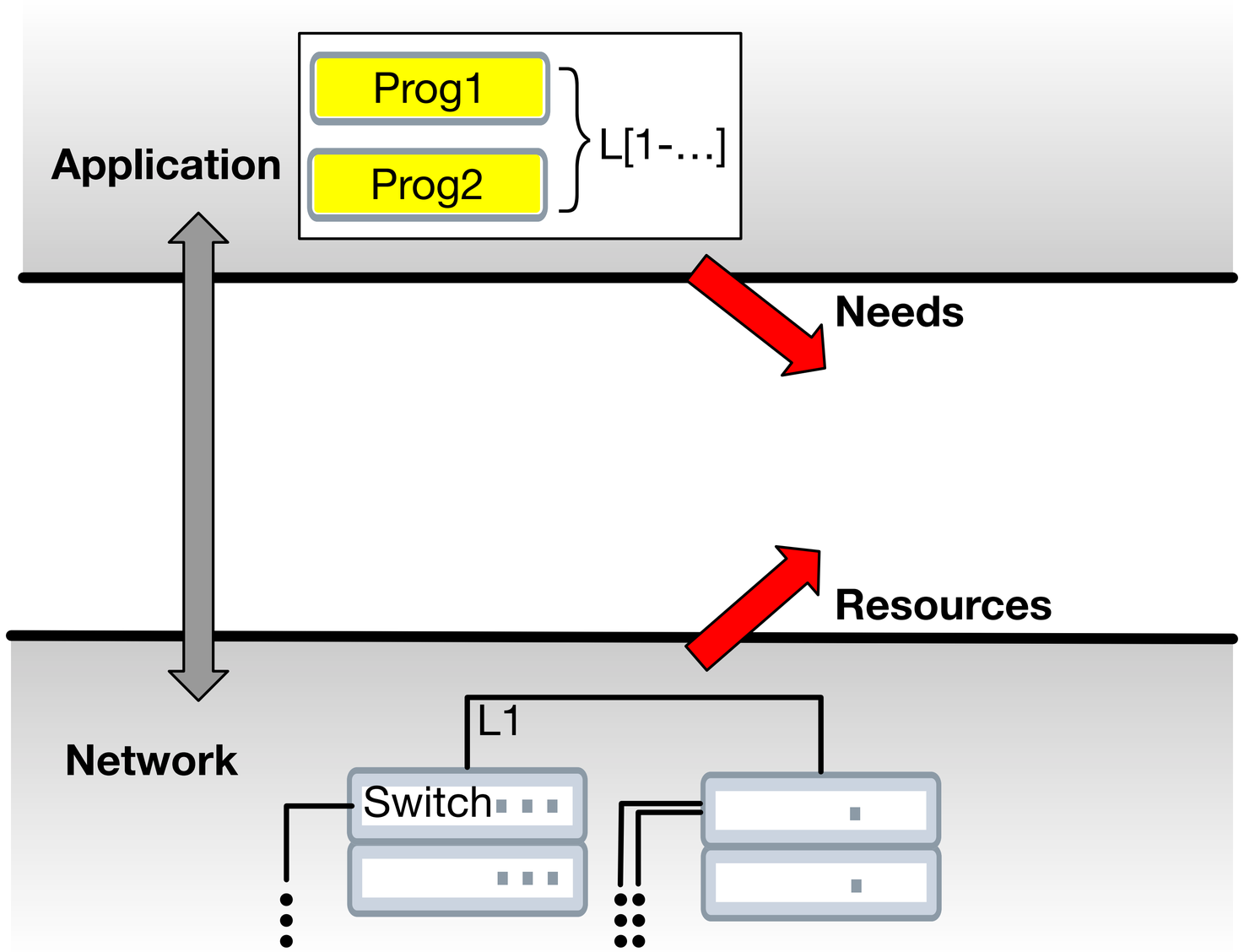
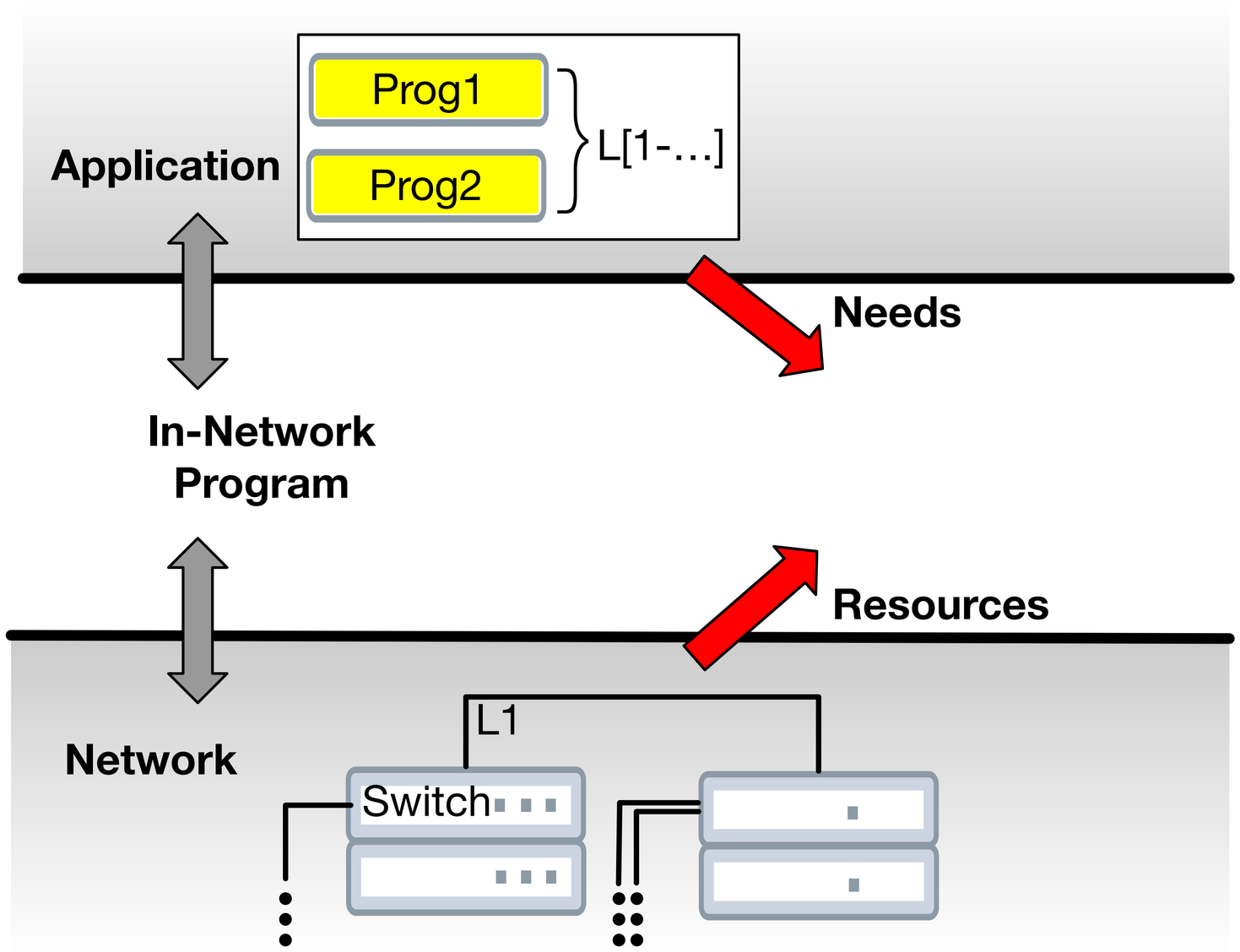
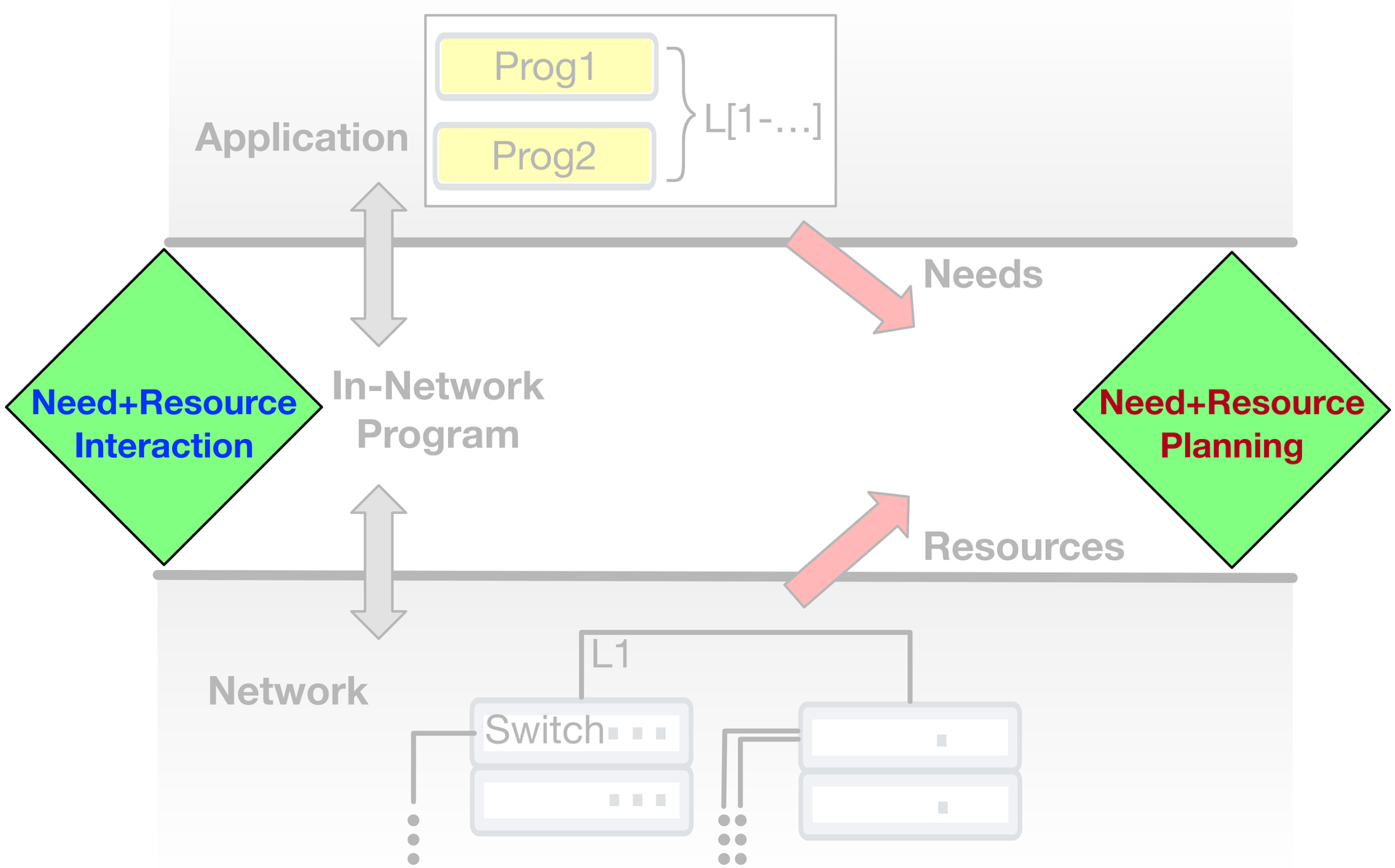
NAI'21

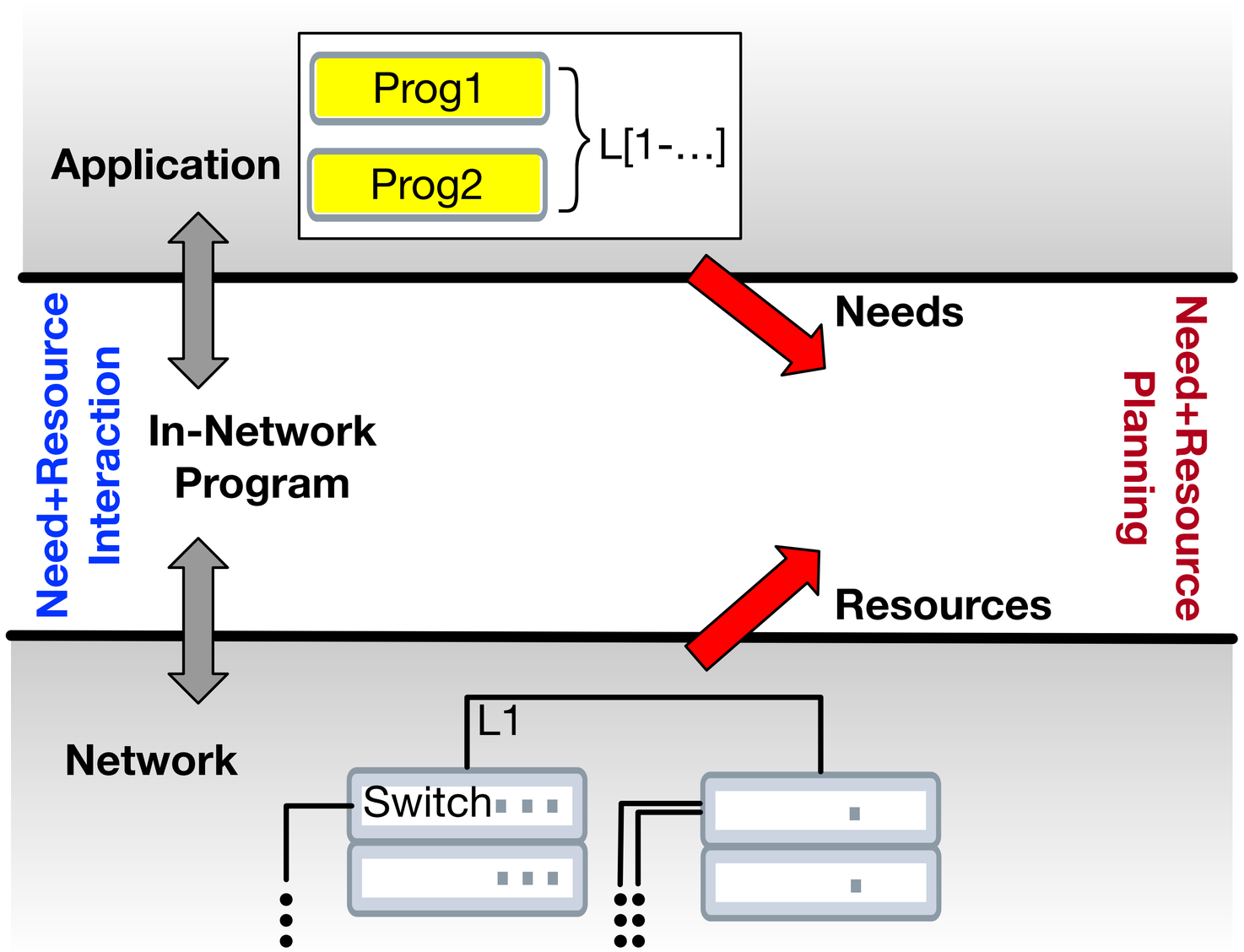

Prog1
Application
Prog2
L1
Network
Switch

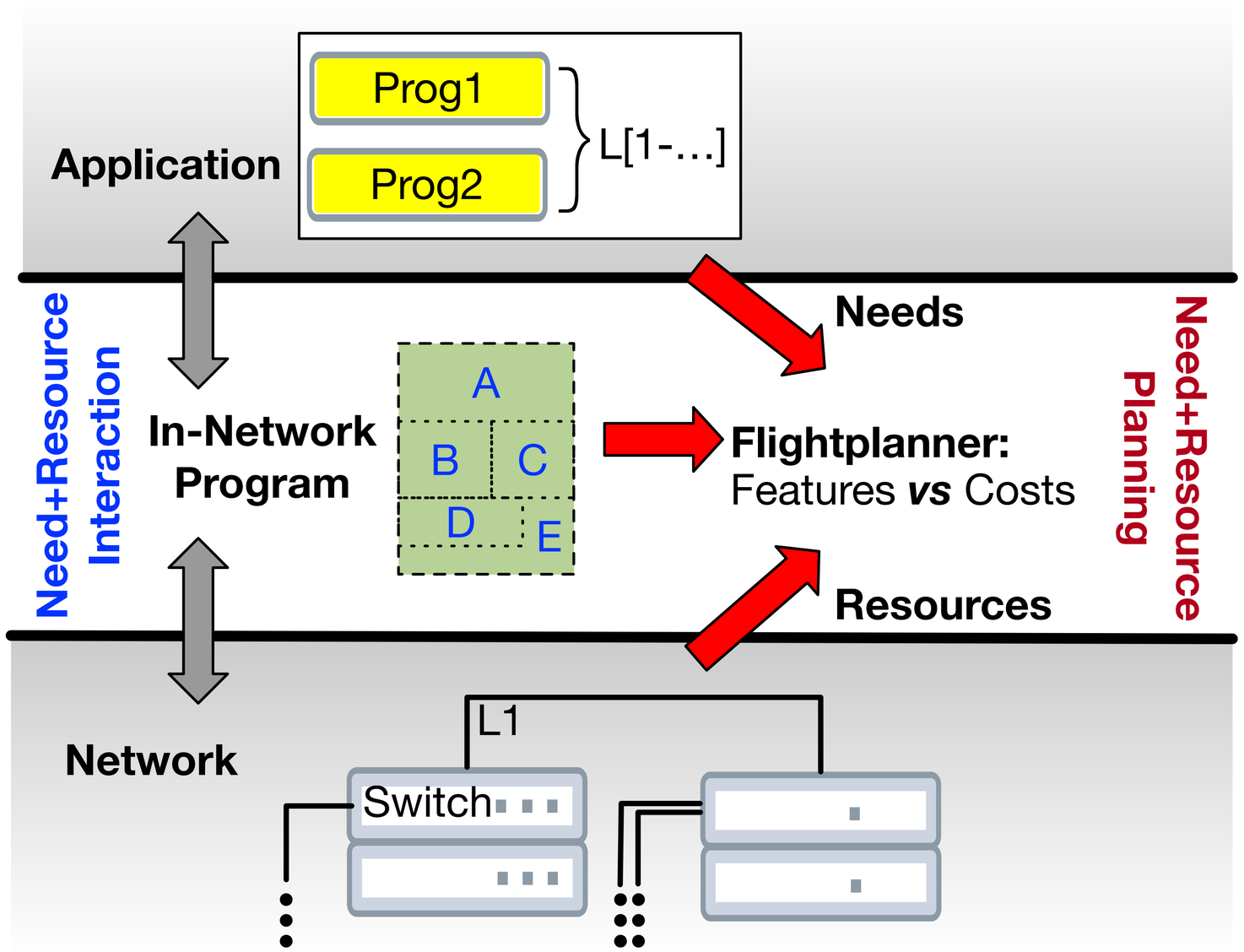

Application
Prog1
Prog2
L[1-…]
Network
L1
Switch


Application
Prog1
Prog2
L[1-…]
Needs
Resources
Network
L1
Switch


Application
Prog1
Prog2
L[1-…]
Needs
In-Network
Program
Resources
Network
L1
Switch


Application
Prog1
Prog2
L[1-…]
Needs
Need+Resource
Interaction
In-Network
Program
Need+Resource
Planning
Resources
Network
L1
Switch


Application
Prog1
Prog2
L[1-…]
Needs
Need+Resource Interaction
In-Network Program
Need+Resource Planning
Resources
Network
L1
Switch


Application
Prog1
Prog2
L[1-…]
Needs
Need+Resource Interaction
In-Network Program
A
B
C
D
E
Flightplanner:
Features *vs* Costs
Need+Resource Planning
Resources
Network
L1
Switch

Flightplan: Dataplane Disaggregation and Placement for P4 programs

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Nishanth Shyamkumar Shivani Burad André DeHon Boon Thau Loo

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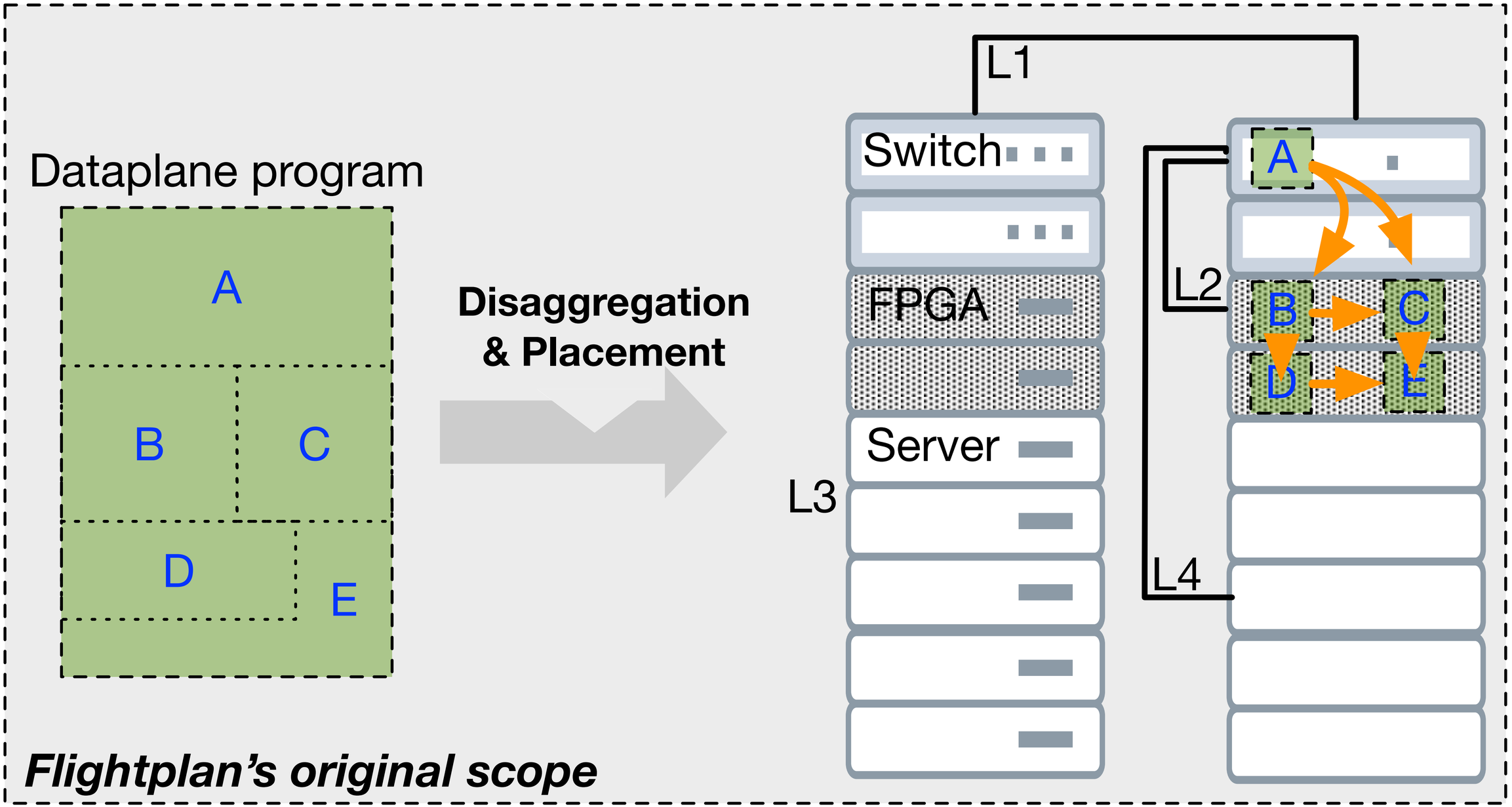
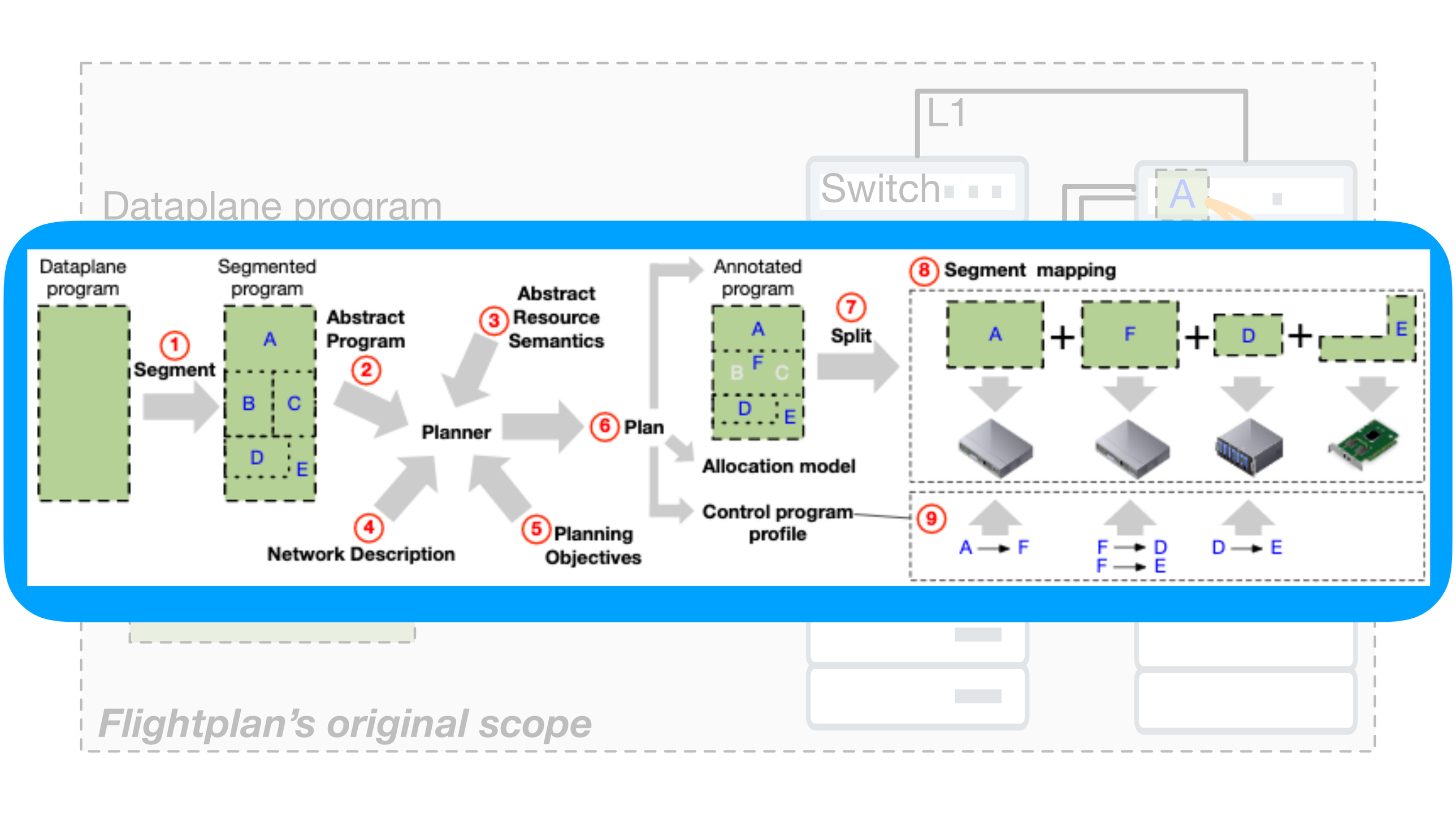
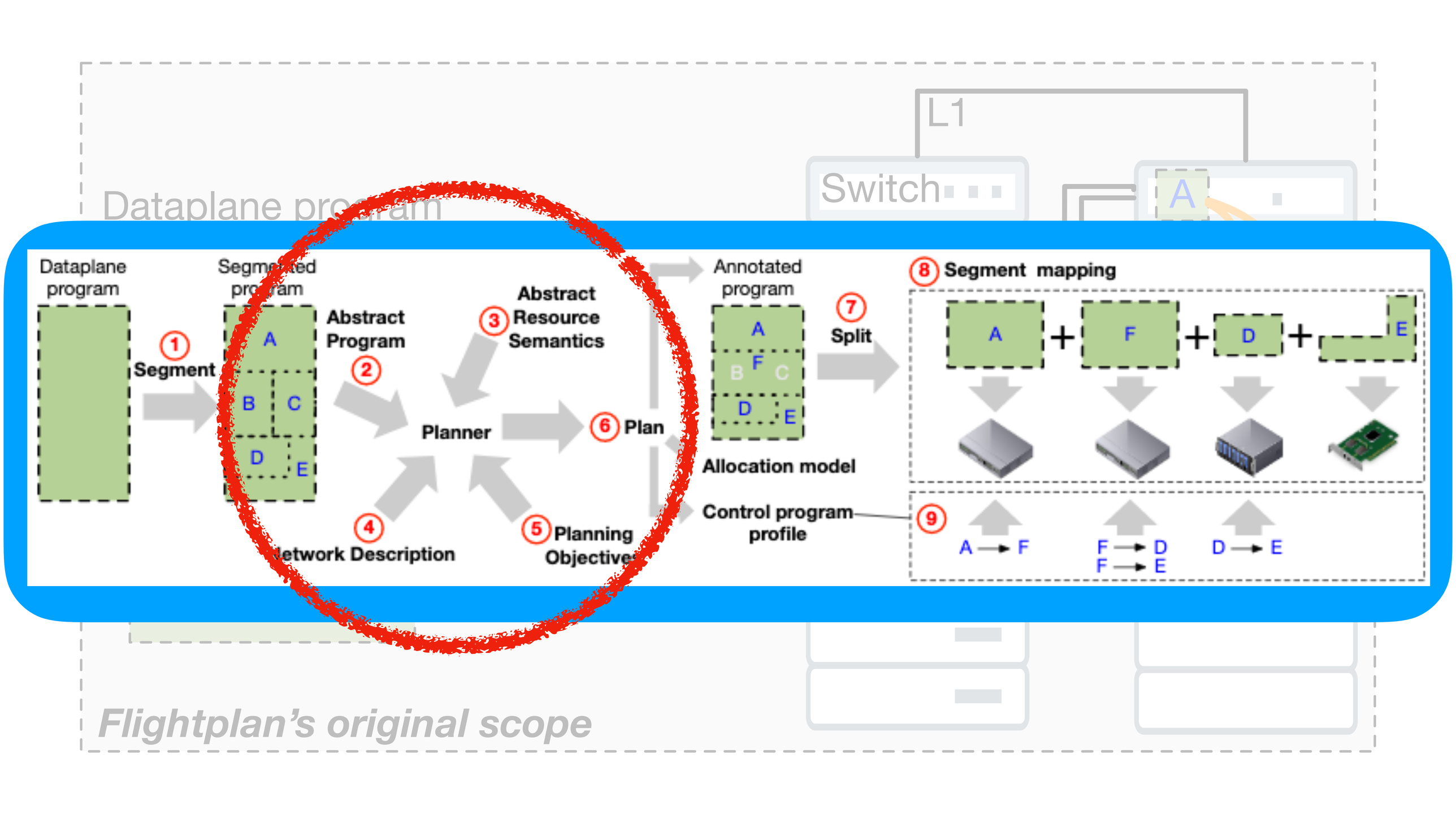
https://flightplan.cis.upenn.edu/


Dataplane program
A
B
C
D
E
Disaggregation
& Placement
L1
Switch
FPGA
Server
L3
L2
L4
A
B
C
D
E
Flightplan's original scope


Dataplane program
L1
Switch
A
Dataplane program
Segmented program
Abstract Program
Abstract Resource Semantics
Annotated program
Split
8 Segment mapping
1 Segment
2
3
7
A
B
C
D
E
F
Planner
6 Plan
Allocation model
Control program profile
4 Network Description
5 Planning Objectives
9
A → F
F → D
F → E
D → E
Flightplan's original scope


Dataplane program
L1
Switch
A
Dataplane program
Segmented program
1 Segment
A
B
C
D
E
Abstract Program
2
3 Abstract Resource Semantics
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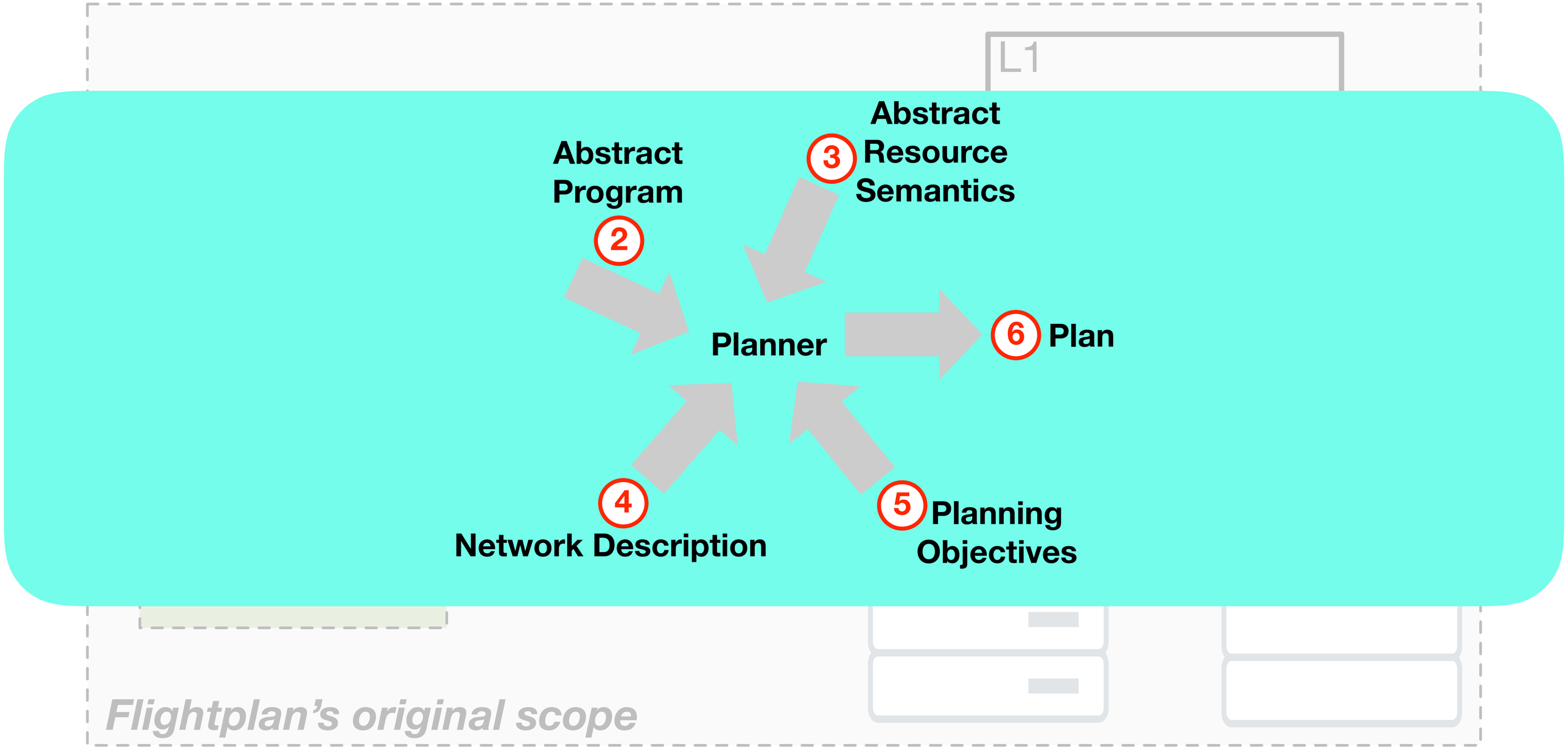
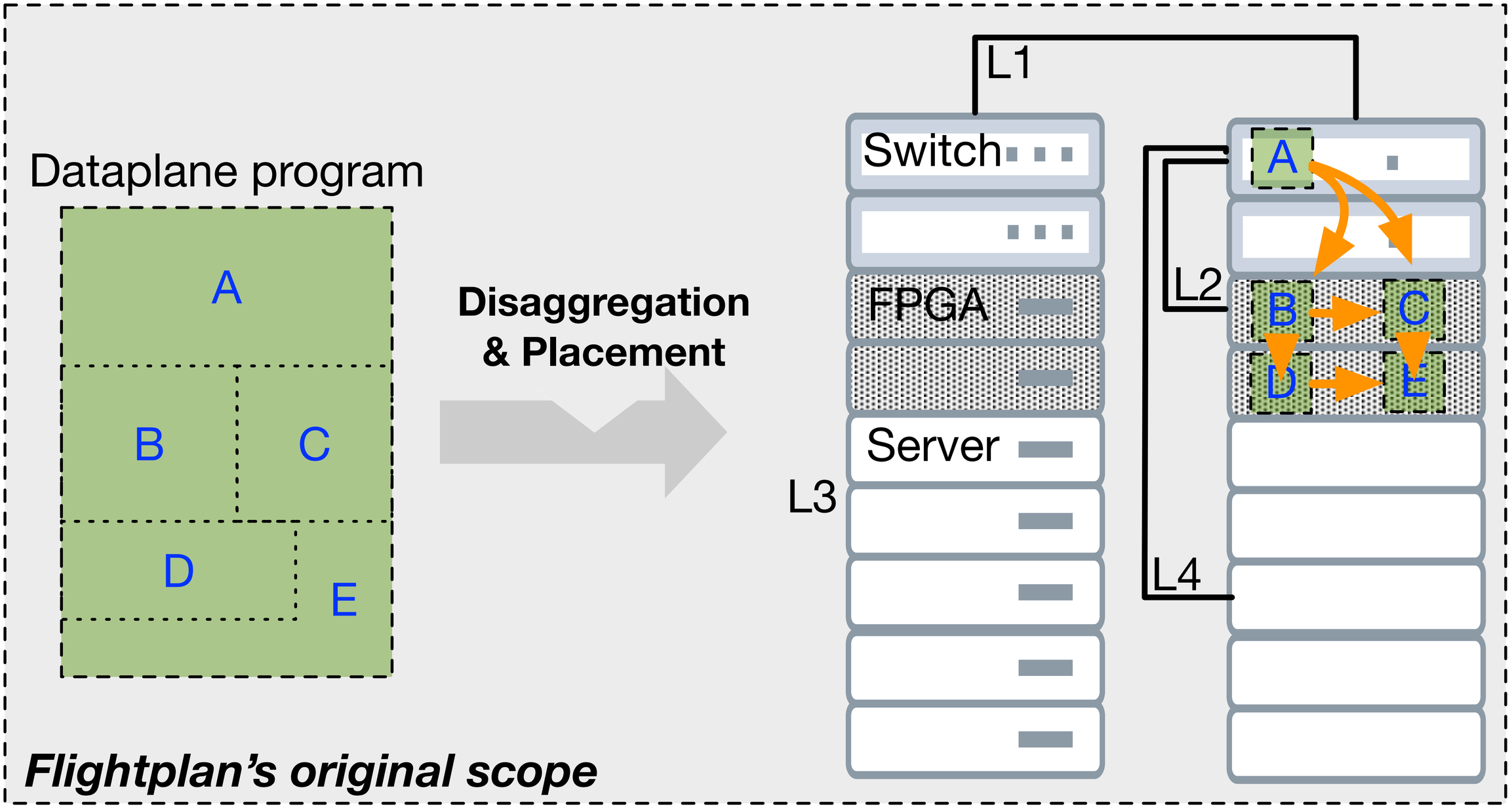
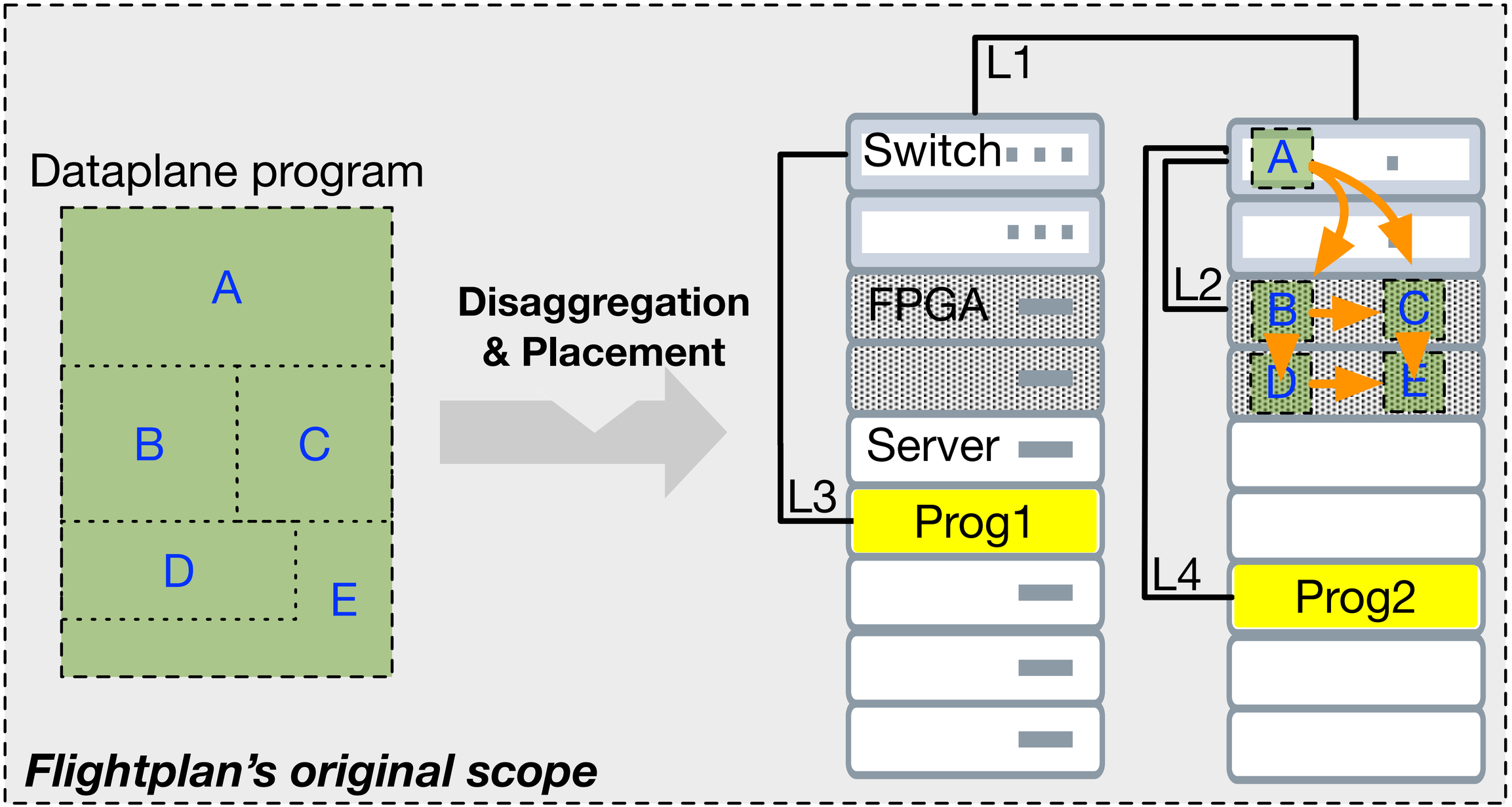
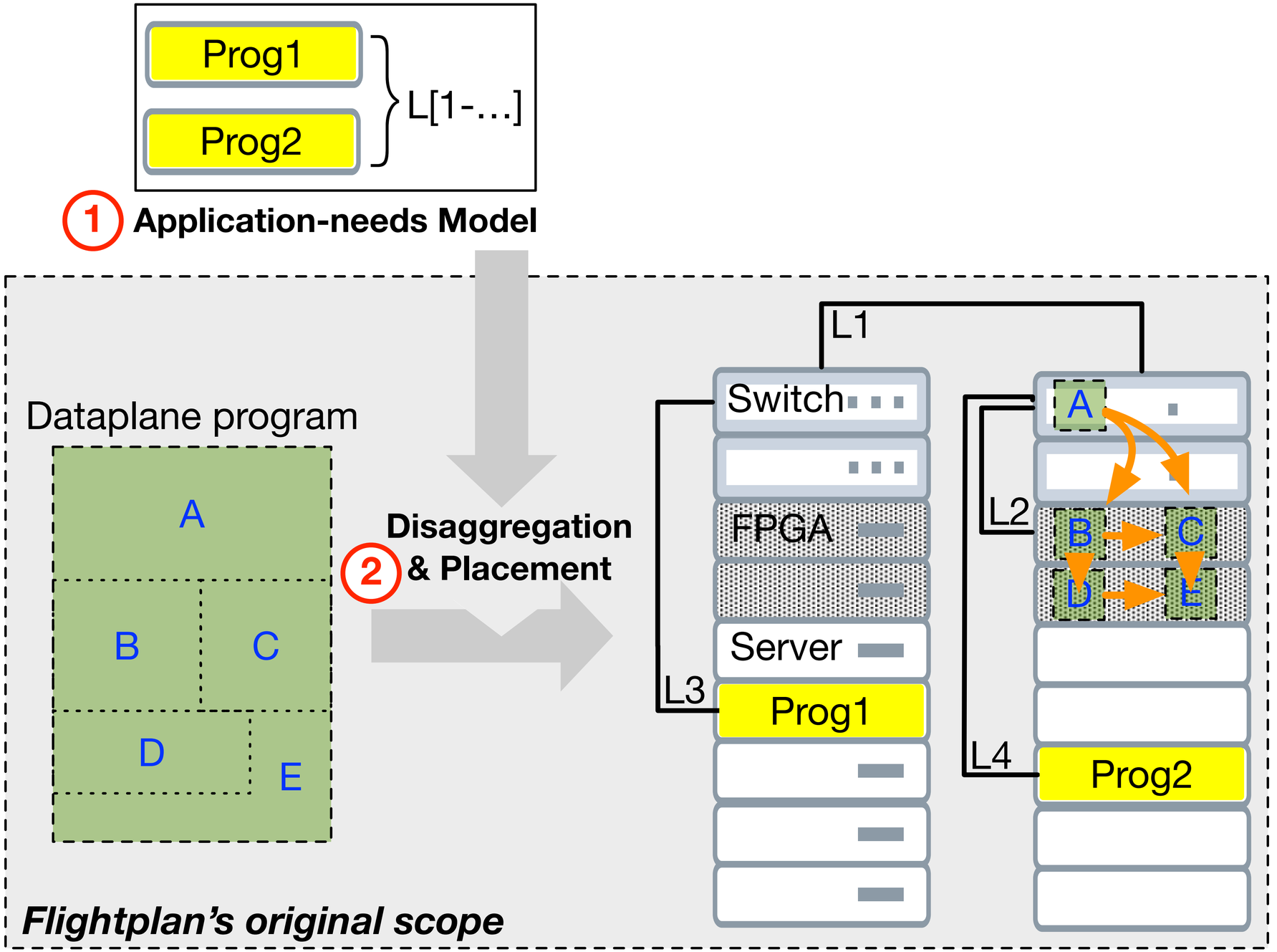
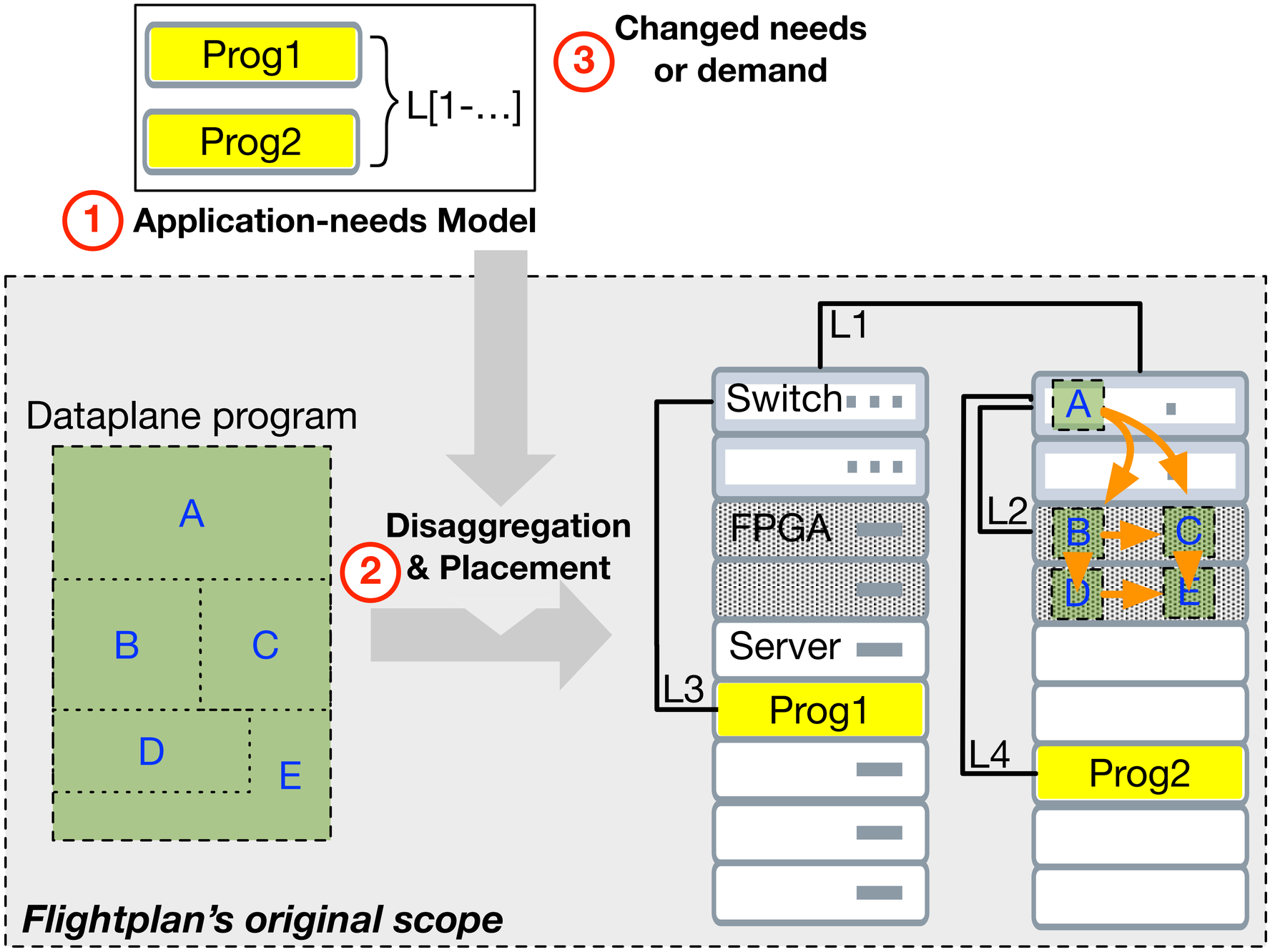
4 Network Description
5 Planning Objectives
Annotated program
A
B
F
C
D
E
Allocation model
Control program profile
7 Split
8 Segment mapping
A
+
F
+
D
+
E
9
A → F
F → D
F → E
D → E
Flightplan's original scope

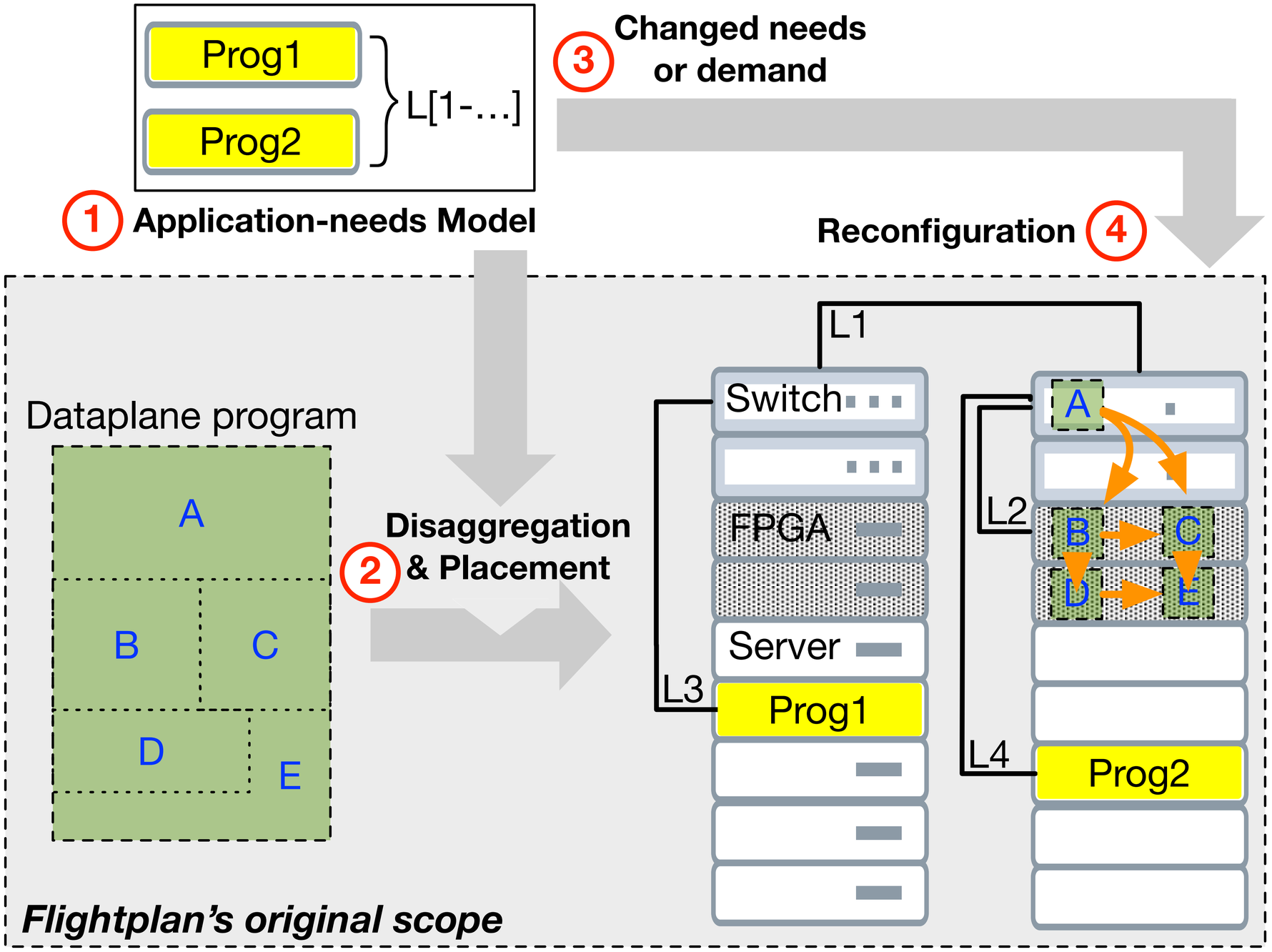

L1
Abstract
Program
2
3
Abstract
Resource
Semantics
Planner
6
Plan
4
Network Description
5
Planning
Objectives
Flightplan's original scope


Dataplane program
A
B
C
D
E
Disaggregation
& Placement
L1
Switch
FPGA
Server
L3
L2
L4
A
B
C
D
E
Flightplan's original scope


Dataplane program
A
B
C
D
E
Disaggregation
& Placement
L1
Switch
FPGA
Server
L3
Prog1
A
L2
B
C
D
E
L4
Prog2
Flightplan's original scope


Prog1
Prog2
L[1-…]
1 Application-needs Model
Dataplane program
A
B
C
D
E
2 Disaggregation & Placement
L1
Switch
FPGA
Server
Prog1
L3
A
L2
B
C
D
E
L4
Prog2
Flightplan's original scope


Prog1
Prog2
L[1-…]
3
Changed needs
or demand
1
Application-needs Model
Dataplane program
A
B
C
D
E
2
Disaggregation
& Placement
L1
Switch
FPGA
Server
L3
Prog1
A
L2
B
C
D
E
L4
Prog2
Flightplan's original scope


Prog1
Prog2
L[1-…]
1 Application-needs Model
3 Changed needs or demand
Reconfiguration 4
Dataplane program
A
B
C
D
E
2 Disaggregation & Placement
L1
Switch
FPGA
Server
L3
Prog1
L2
L4
Prog2
Flightplan's original scope

$$\text{Xeon2450-1}:$$
$$\pi_{\text{Requires}} = \left\{\text{Rate} \leq 10^{10}\right\}, \qquad \pi_{\text{Provides}} = \{\text{CPU}\},$$
$$\text{Ports} = \left\{\ 1 \mapsto \left\{\pi_{\text{Requires}} = \left\{\text{Rate} \leq 10^{10}\right\},\ \pi_{\text{Provides}} = \{\}\right\}\ \right\}$$

Prog1 mode:**M1** :

$\pi_{\text{Requires}} = \{\text{Rate} \leq 1^{10}\}$, $\pi_{\text{Provides}} = \{$ Traffic $\}$,

Ports = {(Xeon2450-1, 1)}, Peers = {Prog2},

OnPath = { InNetProg1 }

Prog1 mode:M1 :

$$\pi_{\text{Requires}} = \{\text{Rate} \leq 1^{10}\}, \quad \pi_{\text{Provides}} = \{\text{Traffic}\},$$
$$\text{Ports} = \{(\text{Xeon2450-1}, 1)\}, \quad \text{Peers} = \{\text{Prog2}\},$$
$$\text{OnPath} = \{\text{InNetProg1}\}$$

Prog1 = mcdClient
Prog2 = mcdServer
Traffic = UDP(200)
M1 = LowActivity (lower π_{Requires})

Prog1 mode:M1 :

$$\pi_{\text{Requires}} = \{\text{Rate} \leq 1^{10}\}, \quad \pi_{\text{Provides}} = \{\text{Traffic}\},$$
$$\text{Ports} = \{(\text{Xeon2450-1}, 1)\}, \quad \text{Peers} = \{\text{Prog2}\},$$
$$\text{OnPath} = \{\text{InNetProg1}\}$$

Prog1 = mcdClient
Prog2 = mcdServer
Traffic = UDP(200)
M1 = LowActivity (lower π_{Requires})
InNetProg1 = (None)

Prog1 mode:M1 :

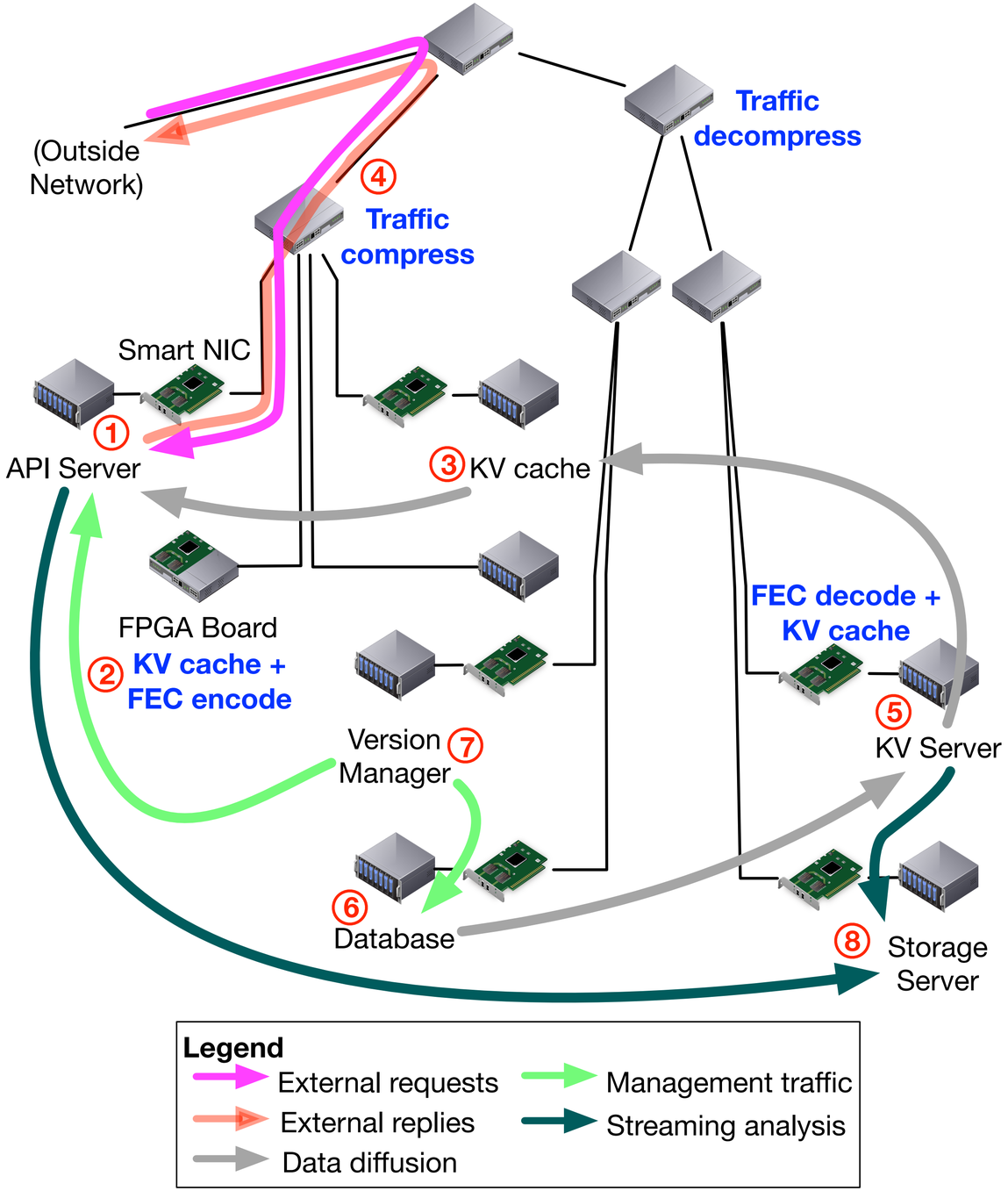
$$\pi_{\text{Requires}} = \{\text{Rate} \leq 1^{10}\}, \quad \pi_{\text{Provides}} = \{\text{Traffic}\},$$

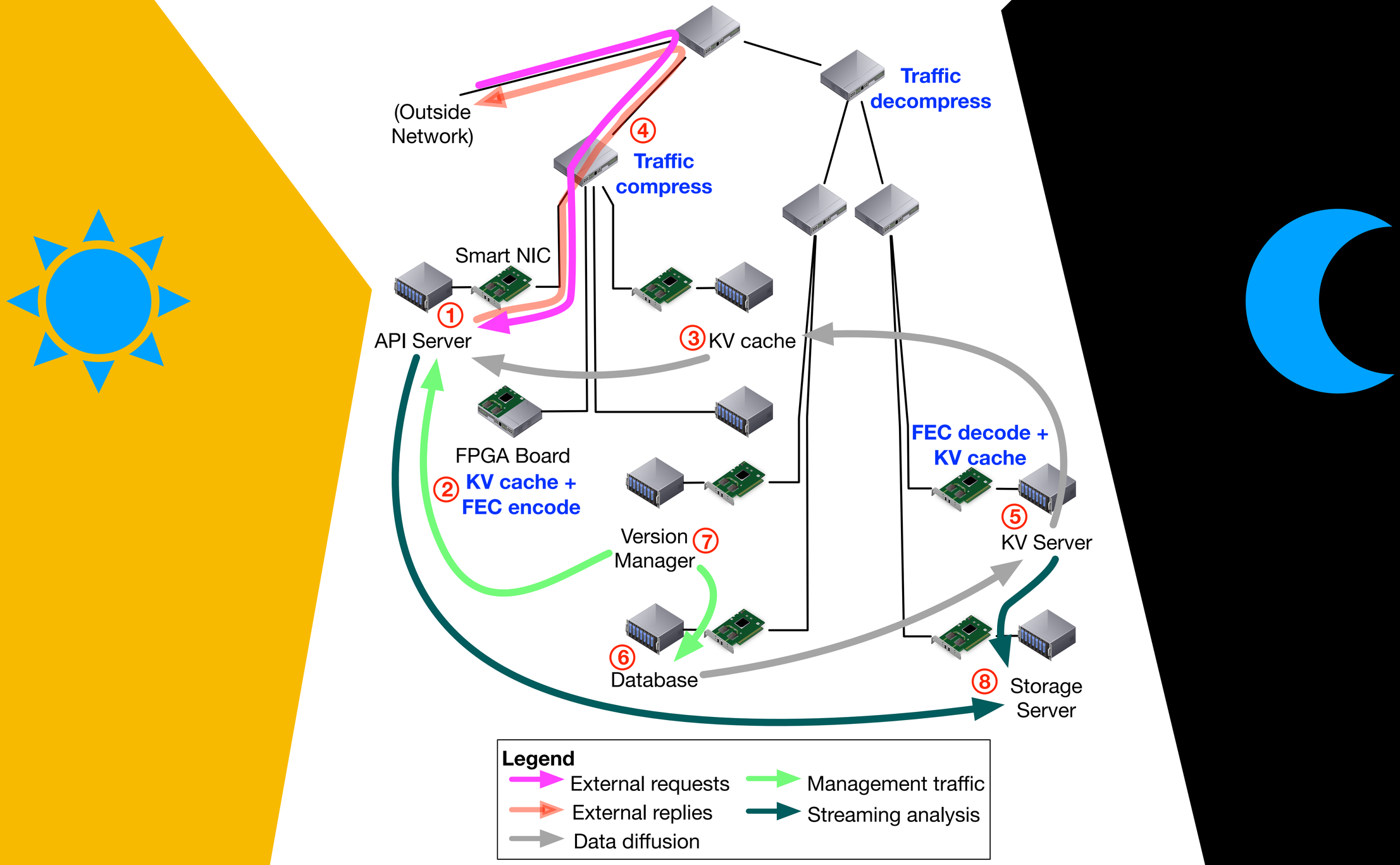
$$\text{Ports} = \{(\text{Xeon2450-1}, 1)\}, \quad \text{Peers} = \{\text{Prog2}\},$$

$$\text{OnPath} = \{\text{InNetProg1}\}$$

Prog1 = mcdClient
Prog2 = mcdServer
Traffic = UDP(200)
M1 = LowActivity
InNetProg1 = (None)

Prog1 = mcdClient
Prog2 = mcdServer
Traffic = UDP(200)
M1 = HighActivity (higher π_{Requires})
InNetProg1 = MCD_Cache


(Outside Network)
Traffic decompress
4
Traffic compress
Smart NIC
1
API Server
3 KV cache
FPGA Board
2 KV cache + FEC encode
FEC decode + KV cache
5
KV Server
Version Manager
7
6
Database
8
Storage Server
Legend
External requests
External replies
Data diffusion
Management traffic
Streaming analysis

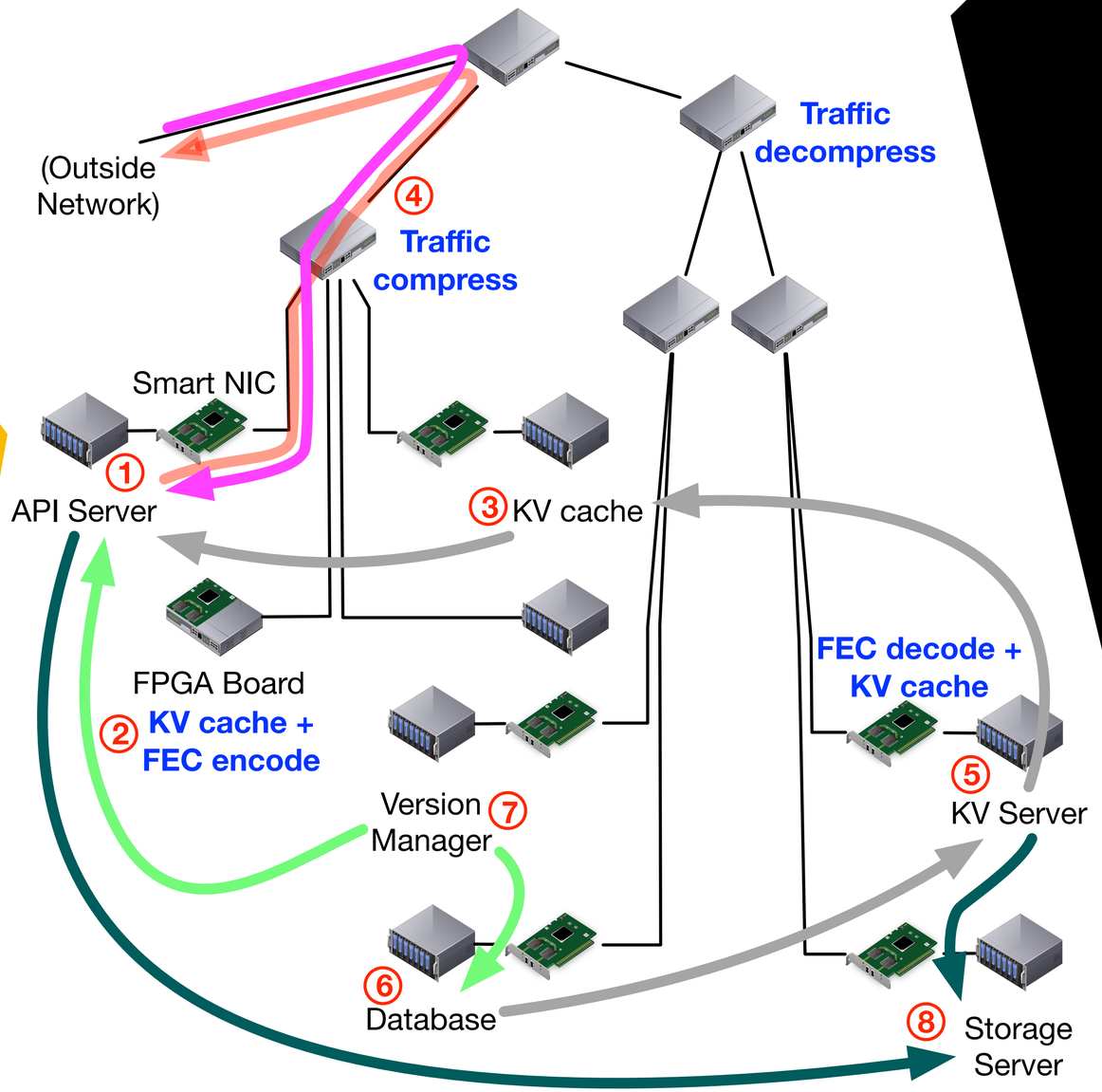

(Outside Network)
Traffic decompress
④
Traffic compress
Smart NIC
①
API Server
③ KV cache
FPGA Board
② KV cache + FEC encode
FEC decode + KV cache
⑤
KV Server
Version Manager
⑦
⑥
Database
⑧
Storage Server
Legend
External requests
External replies
Data diffusion
Management traffic
Streaming analysis

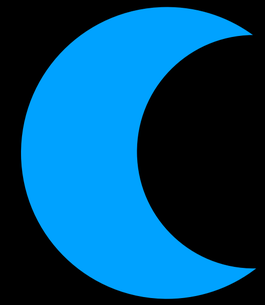
Prog1 mode:M1 :

$$\pi_{\text{Requires}} = \{\text{Rate} \leq 1^{10}\}, \quad \pi_{\text{Provides}} = \{\text{Traffic}\},$$
$$\text{Ports} = \{(\text{Xeon2450-1}, 1)\}, \quad \text{Peers} = \{\text{Prog2}\},$$
$$\text{OnPath} = \{\text{InNetProg1}\}$$

Prog1 = mcdClient
Prog2 = mcdServer
Traffic = UDP(200)
M1 = HighActivity, NightTime
InNetProg1 = MCD_Cache

HTTP
Memcached
rsync





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