

Flow Aggregated, Traffic Driven Label Mapping in Label Switching Networks

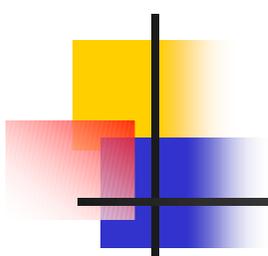
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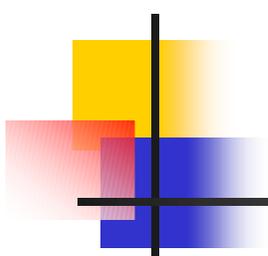
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Outline

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- Label-Mapping Triggers
Granularity of the Packet Stream
- Evaluations of Conventional Label-Mapping Policies
- Flow Aggregated, Traffic-Driven, Label-Mapping Policy
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Introduction

- Recent and upcoming applications often require a specific quality-of-service(QoS) or a class of service(CoS), rather than the conventional best-effort service.
⇒ Label-switching technology satisfies these requirements.
- A *label-switching router (LSR)* forwards layer-3 packets based on their layer-3 address information or their fixed-length label information that is mapped to the layer-3 address.
- The protocol to establish the mappings between the a packet stream and a corresponding label is called a *label-distribution protocol (LDP)*

Introduction

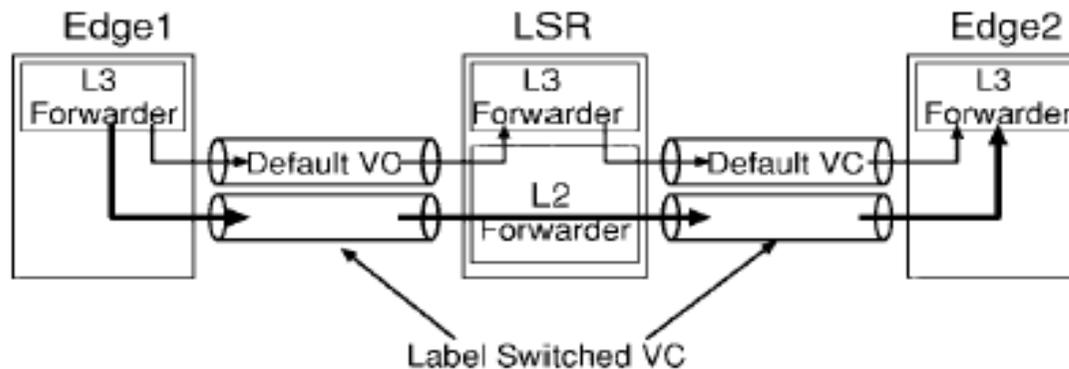
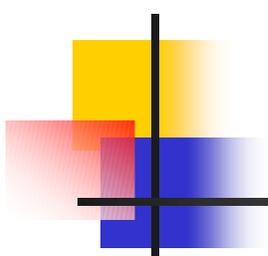


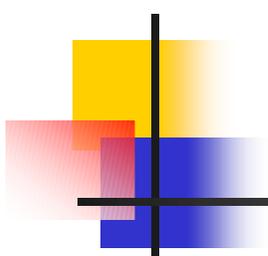
Fig. 1. The LSR.

- The layer-3 forwarding engine looks up the routing table and sends it through the default VC.
- The label-switched VC is used for cut-through packet forwarding.
⇒ The LSR forwards these packets faster than the conventional forwarding because the LSR does not need to look up the layer-3 packet.
- The conjunction of the label-switched VC is called the *label-switched path (LSP)*.



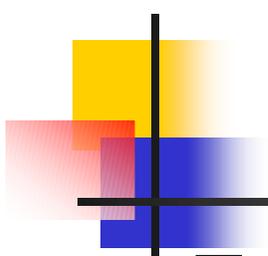
Label-Mapping Triggers

- Traffic-driven mapping
 - The label is mapped to the a packet stream according to the actual packet arrival.
- Topology-driven mapping
 - The label is mapped in advance to the a packet stream using the network-topology information, regardless of actual packet arrival to the LSR.



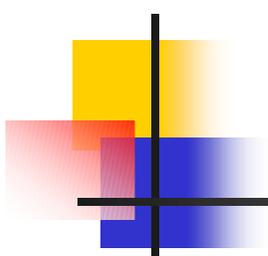
Label-Mapping Triggers

- The definition for the packet stream :
 - host-pair packet stream
 - a set of packets having the same source and destination layer-3 address.
 - ⇒ for traffic-driven mapping
 - destination-network packet stream
 - a set of packets having the same destination-network prefix
 - ⇒ for topology-driven mapping



Label-Mapping Triggers

- Traffic-Driven Mapping
 - The LSP is maintained as long as packets are forwarded through the LSP.
 - When the LSP is not active anymore, it is released.
- Topology-Driven Mapping
 - The LSR maintains the LSP as long as the corresponding routing entry exists.
 - LSR tears down the LSP when the corresponding routing entry is deleted.
- The required amount of label space for traffic-driven mapping is smaller than that for topology-driven mapping



Granularity of the Packet Stream

- In this paper
 - a set of the packets that have the same source and destination address
 - ⇒ denotes as (src,dst)
 - a set of the packets that have the same source address and destination-network prefix
 - ⇒ denotes as (src,dstnet)
 - a set of the packets that have the same source and destination-network prefix
 - ⇒ denotes as (srcnet,dstnet)
 - a set of the packets that have the same destination address
 - ⇒ denotes as (*,dst)
 - a set of the packets that have the same destination-network prefix
 - ⇒ denotes as (*,dstnet)

Evaluated of Conventional Label Mapping Policies

■ Evaluated Traffic Conditions

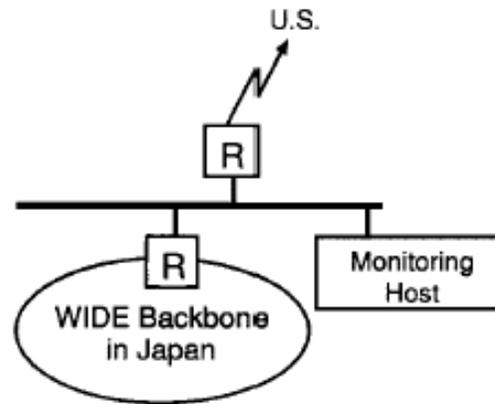
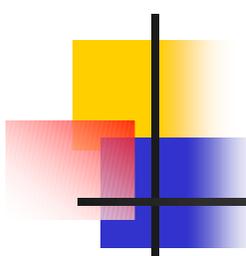


Fig. 2. Traffic-monitoring point.

TABLE I
AVERAGE TRANSFER RATE

Direction	Transfer Rate	Transfer Rate
	[Mbit/s]	[p/s]
to the AS	1.225	329
from the AS	0.926	564

- A traffic monitoring host is located between WIDE (widely integrated and distributed environment) project's Internet backbone network in Japan and the U.S.
- The measurement was performed for 2 hours.



Evaluated of Conventional Label Mapping Policies

- Evaluation for Topology-Driven Mapping
 - Each label is mapped to the destination-network packet stream shown in the routing table entry.

TABLE II
NUMBER OF ROUTING ENTRIES

	In the AS Route	Full Route
Total Entries	2865	50903
Entries directed outside of AS	5	48385
Entries directed inside of AS	2860	2518

⇒ A large number of labels is required with conventional topology-driven mapping for the destination-network packet stream.

Evaluated of Conventional Label Mapping Policies

- Evaluations for Traffic-Driven Mapping
 - Each label is mapped for each host-pair packet stream

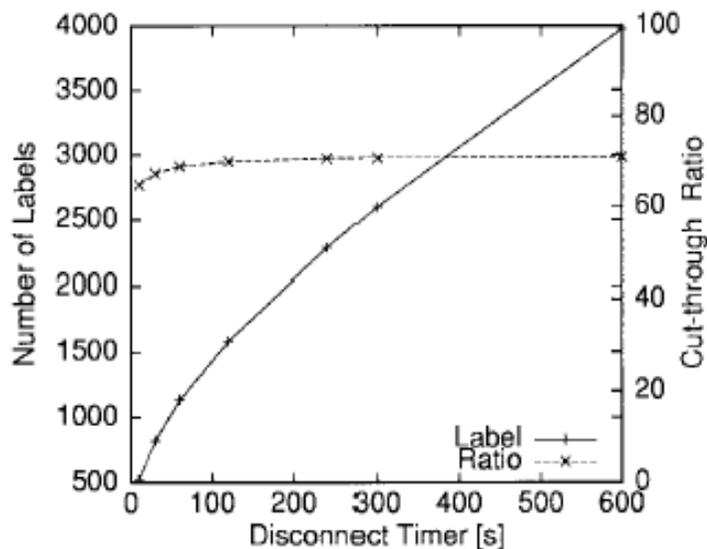


Fig. 3. Number of labels and cut-through ratio directed outside of the AS.

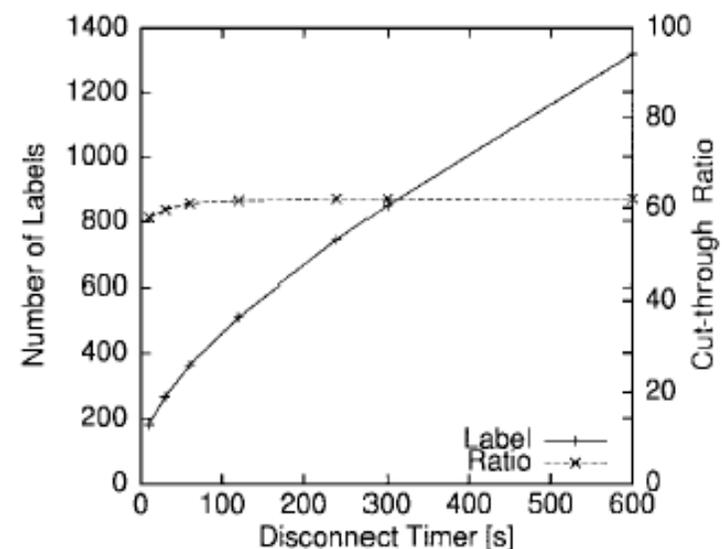
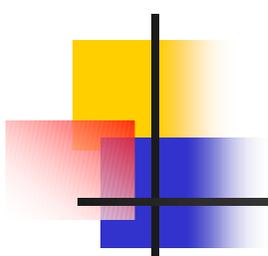


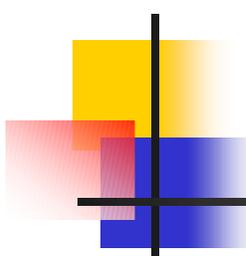
Fig. 4. Number of labels and cut-through ratio directed inside of the AS.

- $\text{cut-through ratio} = \frac{\text{\# of packets transferred through label switching}}{\text{\# of all packets transferred through (label switching + conventional layer - 3 forwarding)}}$



Evaluated of Conventional Label Mapping Policies

- The cut-through ratio is almost the same when the disconnect-timer interval is more than 60ms.
 - ⇒ the disconnect-timer interval is set 60ms.
- The number of labels going out from the AS is 1131.
The number of labels coming into the AS is 365.
 - ⇒ A large number of labels is required with conventional traffic-driven mapping for the host-pair packet stream.



Flow Aggregated, Traffic-Driven, Label-Mapping Policy

- A new label mapping policy is proposed to reduce the number of labels.
- The label is mapped to the packet stream toward a specific destination network triggered by the actual arrival.
⇒ *flow aggregated, traffic-driven, label-mapping policy*

Flow Aggregated, Traffic-Driven, Label-Mapping Policy

- Evaluations with Granularity of Packet Stream
 - (src,dst), (src,dstnet), (srcnet,dstnet), (*,dst), (*,dstnet)

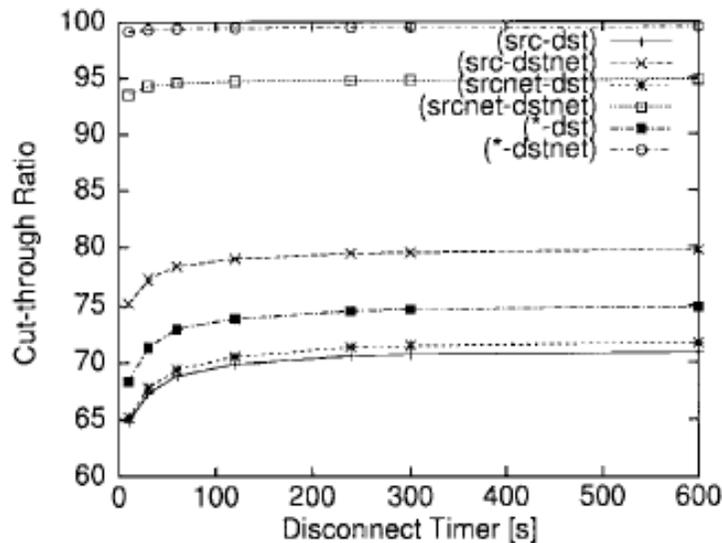


Fig. 9. Cut-through ratio directed outside the AS.

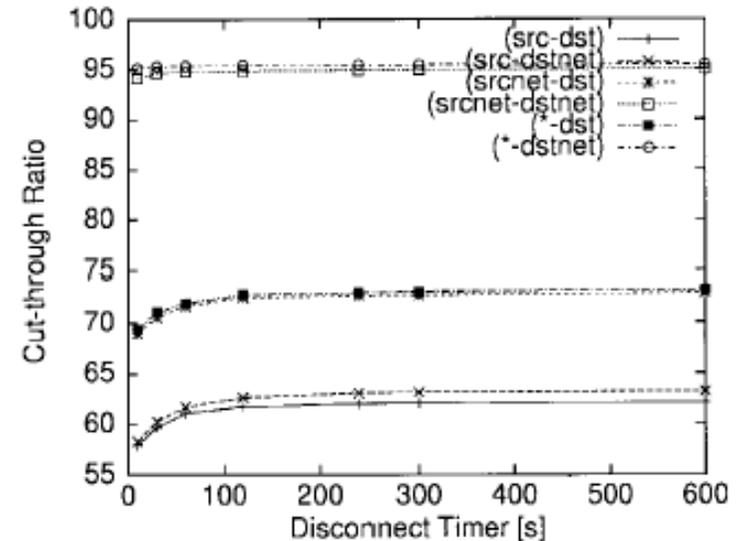


Fig. 11. Cut-through ratio directed inside the AS.

- The cut-through ratios for both incoming and outgoing packets are almost the same when the disconnect timer is more than 60ms.

Flow Aggregated, Traffic-Driven, Label-Mapping Policy

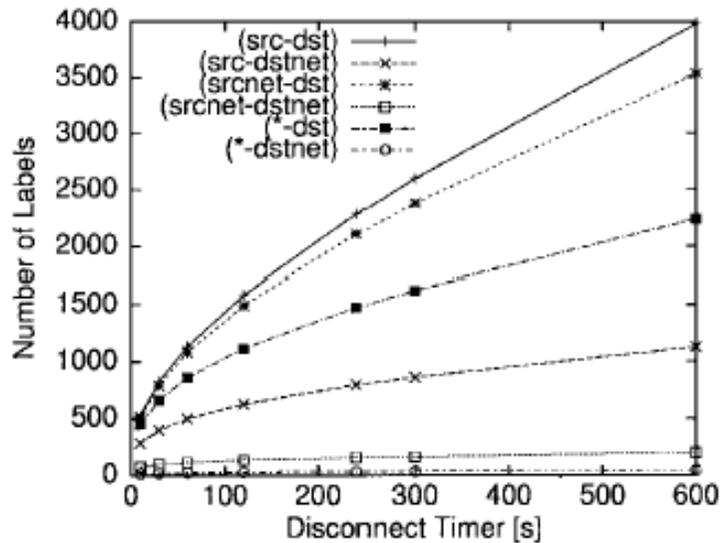


Fig. 8. Number of labels directed outside the AS.

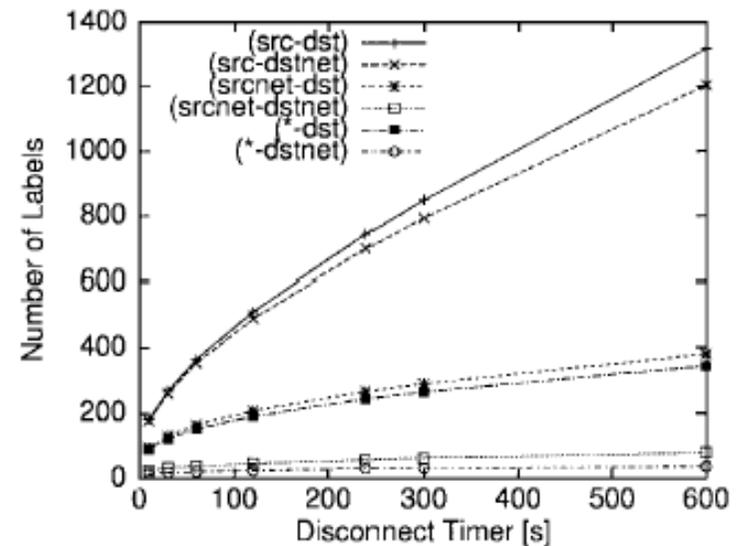


Fig. 10. Number of labels directed inside the AS.

Flow Aggregated, Traffic-Driven, Label-Mapping Policy

TABLE III
NUMBER OF LABELS AND CUT-THROUGH RATIO DIRECTED OUTSIDE THE AS

Granularity	Number of Labels	Cut-through Ratio
(src, dst)	1131	68
(* , dst)	859	73
(src, dstnet)	498	78
(srcnet, dstnet)	113	94
(* , dstnet)	99	99

TABLE IV
NUMBER OF LABELS AND CUT-THROUGH RATIO DIRECTED INSIDE THE AS

Granularity	Number of Labels	Cut-through Ratio
(src, dst)	365	61
(src, dstnet)	353	62
(* , dst)	152	72
(srcnet, dstnet)	38	95
(* , dstnet)	21	95

- Outside the AS
 - The number of labels is only 99 \Rightarrow more than 10 times less
 - The cut-through ratio increases from 68% to 99%
- Inside the AS
 - The number of labels is only 21 \Rightarrow 17 times less
 - The cut-through ratio increases from 61% to 95%

Flow Aggregated, Traffic-Driven, Label-Mapping Policy

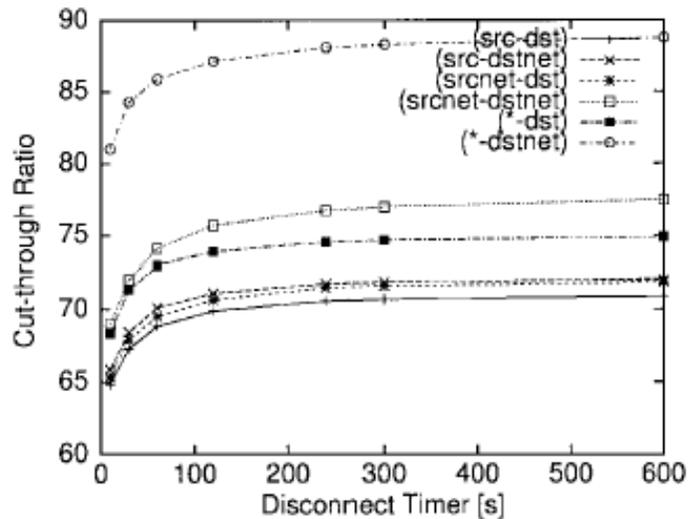


Fig. 13. Cut-through ratio directed outside the AS using full route.

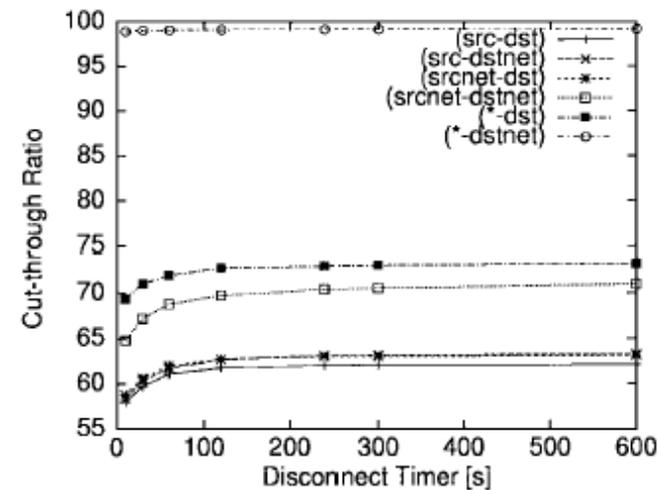


Fig. 15. Cut-through ratio directed inside the AS using full route.

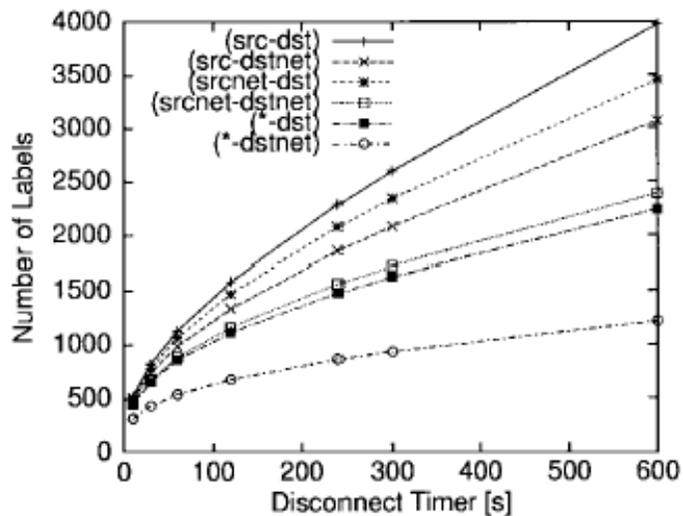


Fig. 12. Number of labels directed outside the AS using full route.

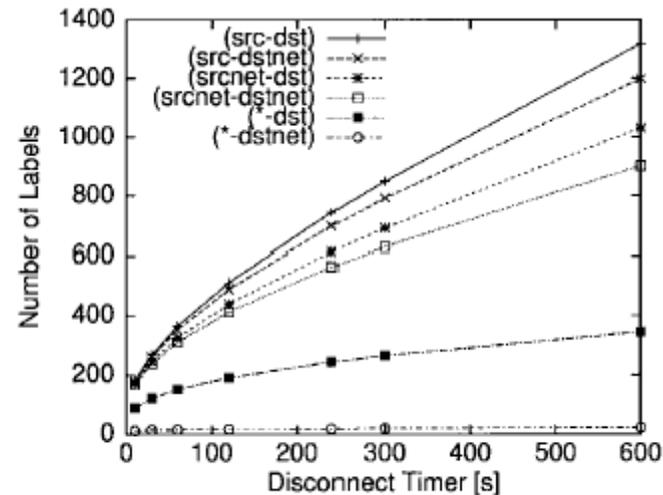


Fig. 14. Number of labels directed inside the AS using full route.

Flow Aggregated, Traffic-Driven, Label-Mapping Policy

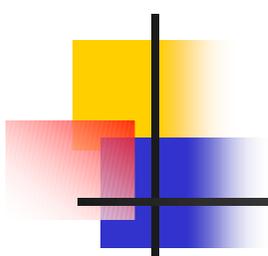
TABLE V
NUMBER OF LABELS AND CUT-THROUGH RATIO
DIRECTED OUTSIDE THE AS WITH FULL ROUTE

Granularity	Number of Labels	Cut-through Ratio
(src, dst)	1131	68
(src, dstnet)	990	70
(* , dst)	859	73
(srcnet, dstnet)	883	74
(* , dstnet)	542	86

TABLE VI
NUMBER OF LABELS AND CUT-THROUGH RATIO
DIRECTED INSIDE THE AS WITH FULL ROUTE

Granularity	Number of Labels	Cut-through Ratio
(src, dst)	365	61
(src, dstnet)	352	62
(srcnet, dstnet)	310	69
(* , dst)	152	72
(* , dstnet)	16	99

- Outside the AS with full route
 - The number of labels is 543 \Rightarrow 2 times less
 - The cut-through ratio increases from 68% to 86%
- Inside the AS with full route
 - The number of labels is 16 \Rightarrow 22 times less
 - The cut-through ratio increases from 61% to 99%



Conclusion

- The number of required labels depends on the *label-mapping triggers*, *the granularity of packet stream*, and *the scale of the network*.
- The proposed policy uses label mapping with aggregated packet stream toward a specific destination network, triggered by the actual packet arrival belonging to the defined aggregated packet stream.
- The evaluation results show that traffic-driven mapping with flow aggregation decreases the number of required labels and also increases the cut-through ratio.