Enhancing
the Quality of Service
for the future Internet
— KUMA Project

KUPF: 2-Phase Selection Model of Classification Records

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Background

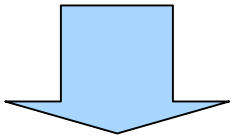
- Many Internet services classify the data to be handled according to rules which control the service.
  - » Firewall classifies incoming/outgoing packets.
  - » QoS mechanism classifies data flow.
- Internet services contain many control rules.
- Classification mechanism is important.
  - » Every data is classified by its parameter, and controlled by rule.

How to Decide the Action

- How does a router decide the action?
  - » classify data and decide the action corresponding with its data
  - » examples:
    - – router: decision on next hop by destination address
    - – firewall: filter rules with parameters on a packet
- Conventional system:
  - » Each vender has each implementation.
  - » Routing, diff-serv, firewall mechanisms on same node individually proceed classification.

Goal

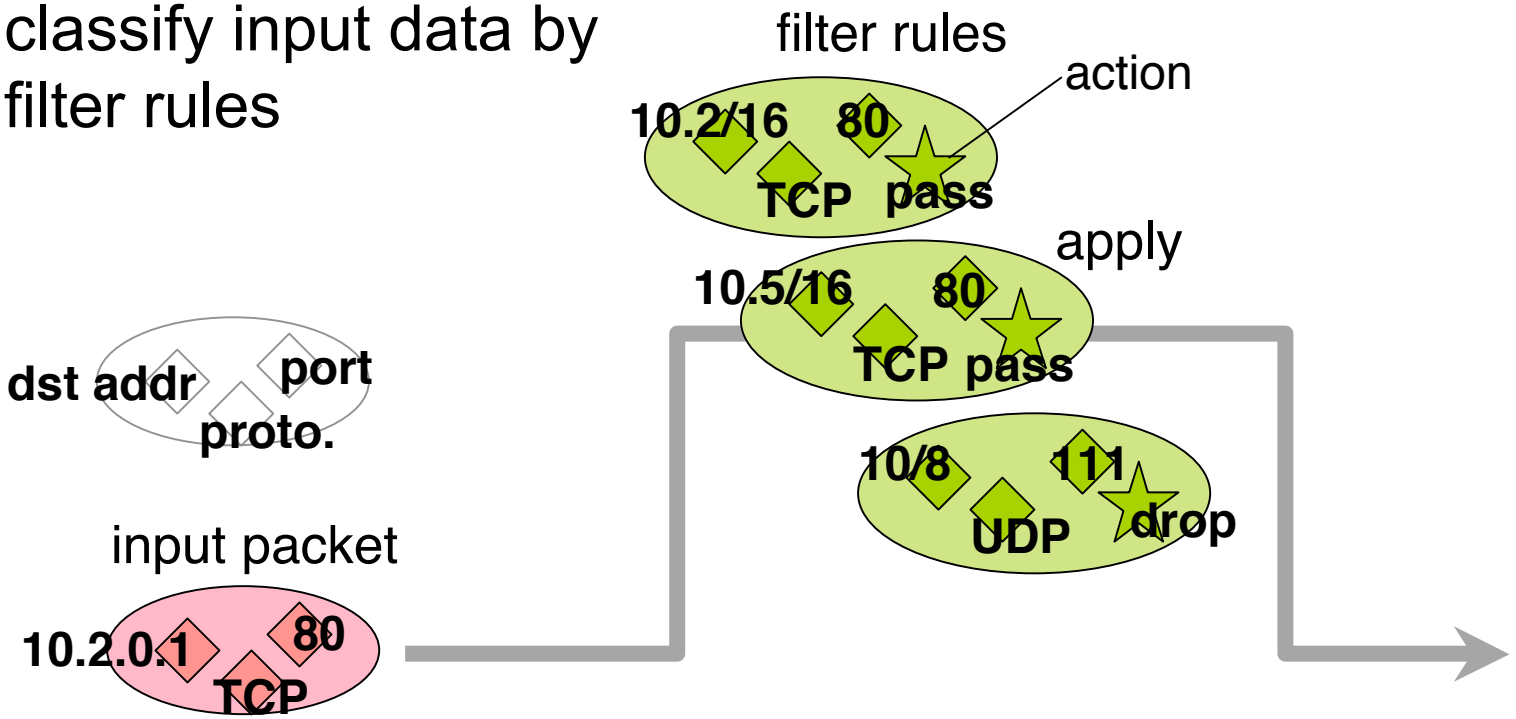
- Generalization of packet classification mechanism
- Parameter Filter
  - » Build a model
  - » Develop a framework



- Represent filter rule using common style
  - » Save time of network administrator
- Integration of procedures of parameter filter
  - » Efficient development of a system

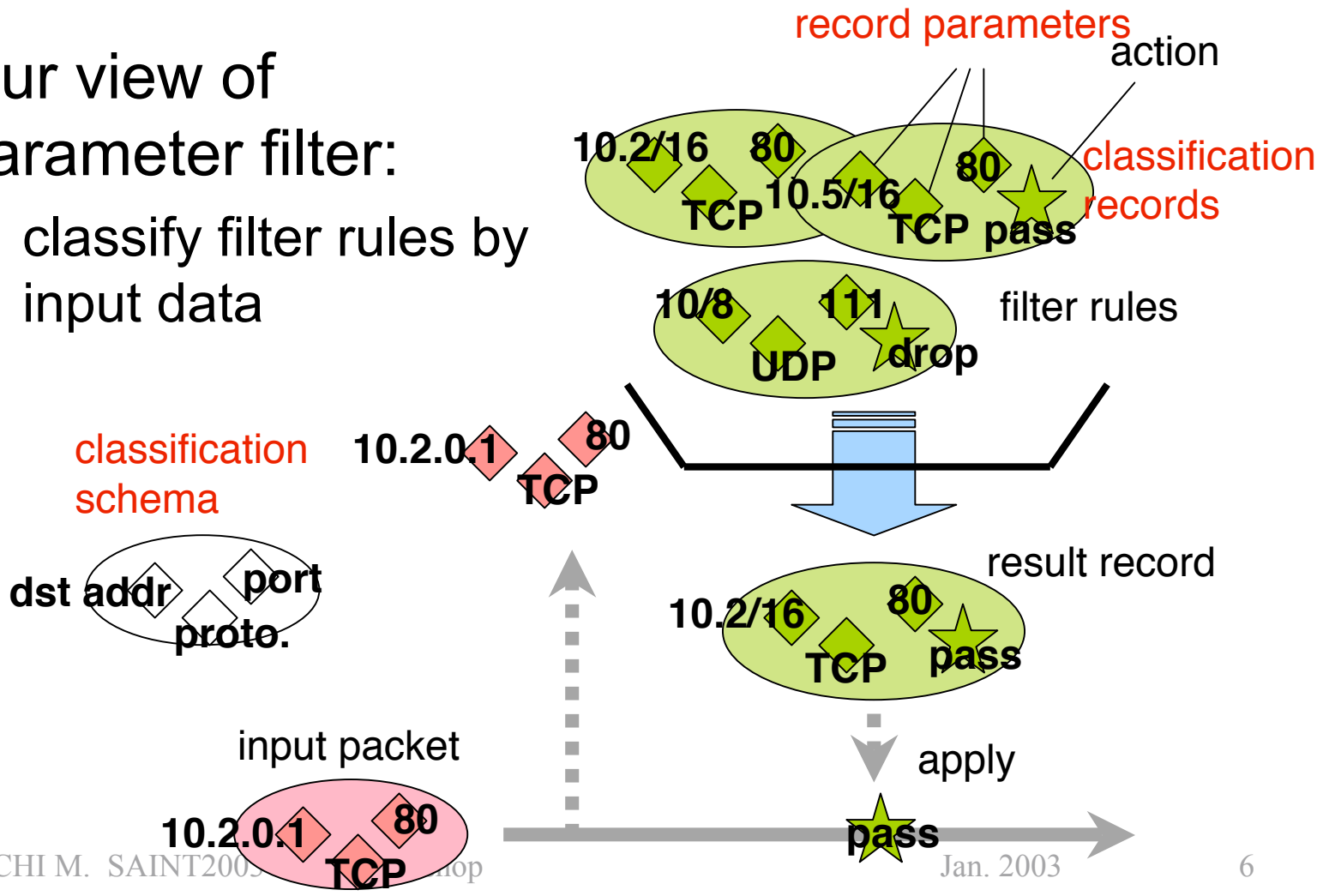
Model (1/2)

- Conventional view of parameter filter:
  - » classify input data by filter rules



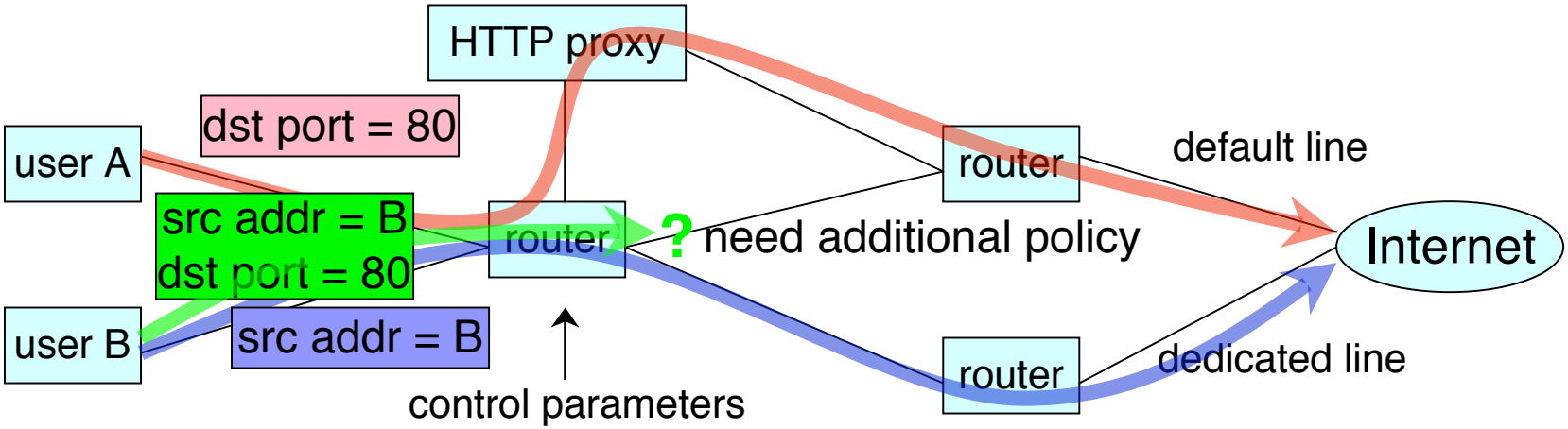
Model (2/2)

- Our view of parameter filter:
  - » classify filter rules by input data



Conflict of Rules

- Some rules compete with other.
- example:
  - » HTTP requests should pass through proxy server.
  - » User B uses dedicated line.



src addr	dst port	action
*	80	to HTTP proxy
B	*	to dedicated line

*: wild card

2-Phase Selection Model (1/2)

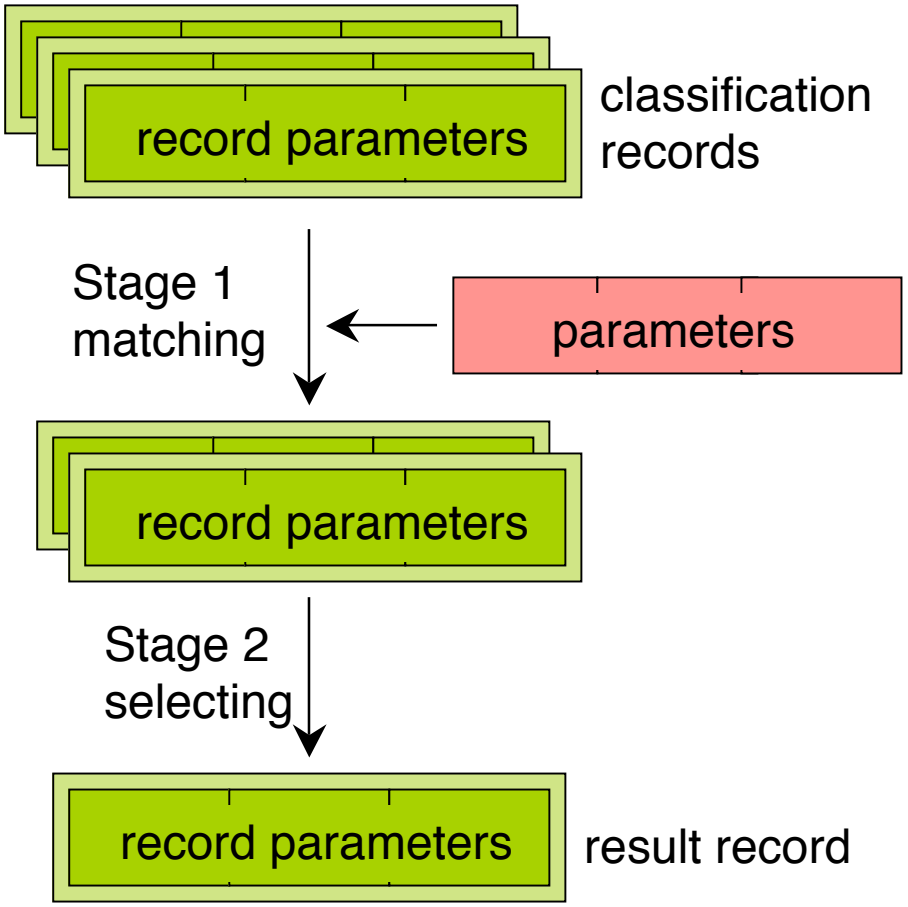
- Stage 1:
  - » Selecting records with filter rule which satisfy target from classification records
  - » Stage 1 selection is:
    - – independent of services
    - – dependent only on parameter matching
- Stage 2:
  - » Selecting records with action which applies to target from satisfied records
  - » Stage 2 selection is:
    - – dependent on services and policy

2-Phase Selection Model (2/2)

- 2-phase selection model divides parameter filter into two parts:
  - » independent of services
  - » dependent on services
- We take only Stage 2 into consideration, even in following cases:
  - » investigating and solving conflicts of record selection
  - » investigating and solving inconsistency between multiple routers
  - » implementing schema and policy for a new service

Implementation of KUPF

- KUMA*'s Universal Parameter Filter (KUPF)
  - » framework of parameter filter based on 2-phase selection model
  - » NetBSD
  - » C language
  - » Running on both kernel land and user land



*KUMA Project: http://www.kuma-project.net/

Parameter

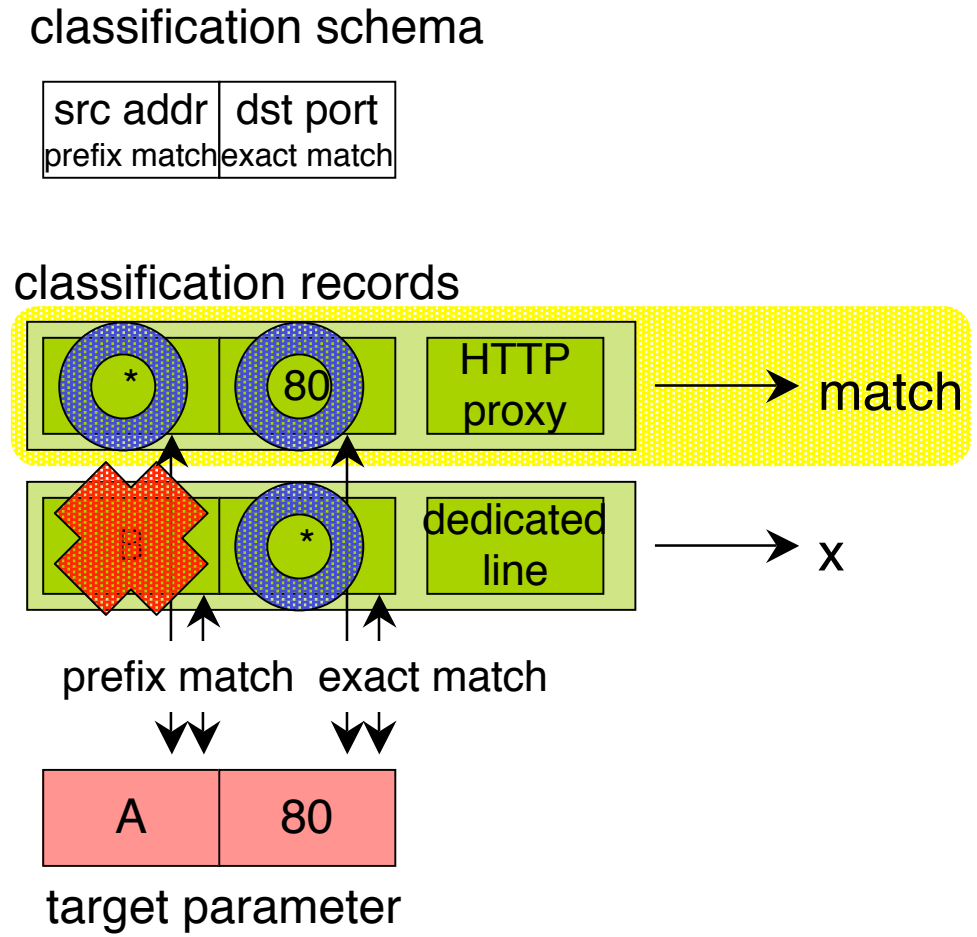
- Implemented 4 fundamental types
  - » integer
    - – port number, protocol number
  - » bit stream
    - – IPv4 / IPv6 address
  - » byte stream
    - – character string
  - » special: *any*
    - – *any* matches with to any parameter by all method

Comparison Method

- Compare with parameter
  - » match
    - – port number, protocol number
  - » mask match
    - – TOS (Type of Service)
  - » prefix match
    - – IPv4 / IPv6 address
- Users can add other method.

Stage 1

- Stage 1 compares whole classification records with target parameter and output matched classification records.
- Classification table is managed by linear list.



Stage 2

- Stage 2 heavily depends on the service.
- We provide a sample implementation.

Example of Implementation

- Replace parameter filter of ALTQ (queueing and shaping mechanism) with KUPF
- ALTQ applies a single action for each incoming packet.
- We implemented a Stage 2 based on best match policy.

Classification Schema for IPv6 and Record Parameter (extract)

attribute	fundamental type (length)	record parameter (length)	compare
protocol	unsigned integer	unsigned integer	match
traffic class	bit stream (8 bits)	bit stream (8 bits) bit stream (8 bits)	mask match
dst address	bit stream (128 bits)	variable length bit stream	prefix match
src address	bit stream (128 bits)	variable length bit stream	prefix match
dst port	unsigned integer	unsigned integer	match
src port	unsigned integer	unsigned integer	match

Experimentation (1/2)

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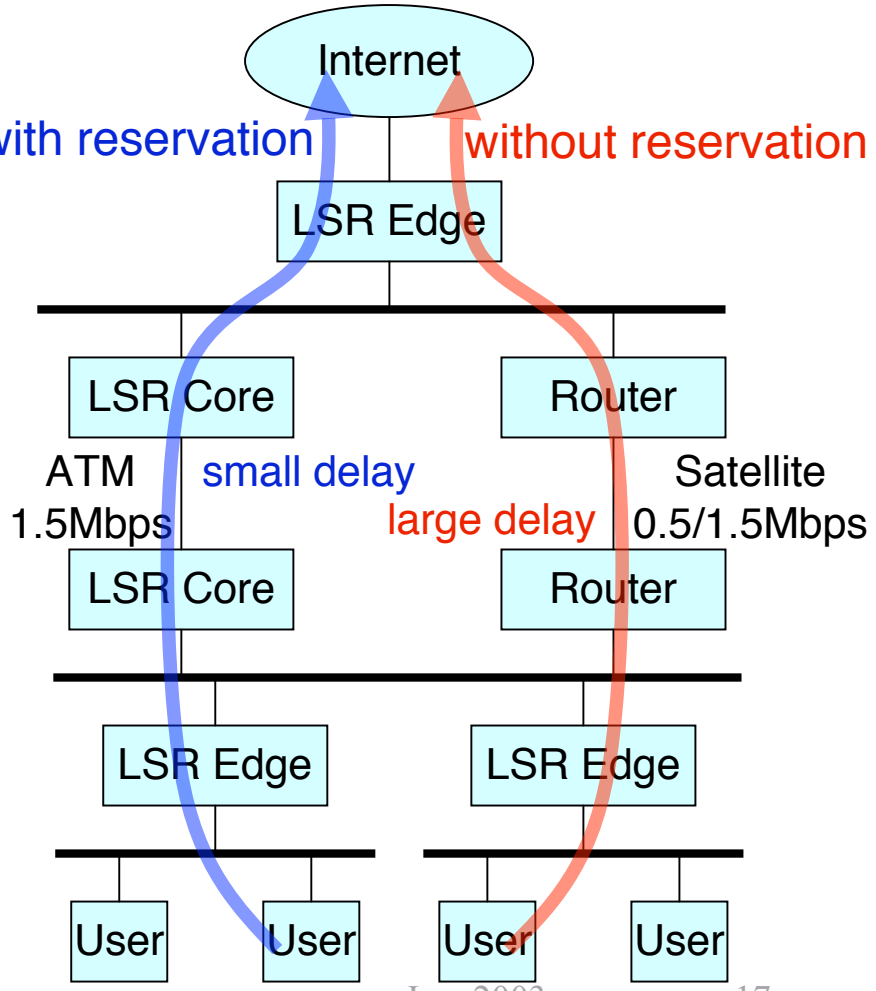
Kuma Project

- We provided 273 users with IPv4 / IPv6 network
- Users demanded network resource.
- Reservation parameters
  - » ATM / Satellite
  - » Bandwidth, time
  - » src & dst addresses
  - » protocol
  - » src & dst port numbers



Experimentation (2/2)

- KUPF and ALTQ was used on Label Switching Router (LSR).
- KUPF decided label and queueing parameter based on rules.
- KUPF provided users with stable network.

Performance Evaluation (1/2)

- NetBSD 1.6, Pentium III 1GHz
- 1,000 filters (received interface, protocol, destination address, destination port number)
- median of 10 averages of 1,000 times

filter	interface	protocol	dst addr	dst port
IPv4 host	fxp0	UDP	192.168.4.0, .., 192.168.4.9	10,000, .., 10,099
IPv4 net	fxp0	UDP	192.168.4.0/28, .., 192.168.4.144/28	10,000, .., 10,099
IPv6 host	fxp0	UDP	fec0:0:0:4::0, .., fec0:0:0:4::9	10,000, .., 10,099
IPv6 net	fxp0	UDP	fec0:0:0:4000::/64, .., fec0:0:0:4009::/64	10,000, .., 10,099

Performance Evaluation (2/2)

filter	ALTQ	KUPF (0% hit)	KUPF (50% hit)
IPv4 host	0.002 ms	0.65 ms	0.34 ms
IPv4 net	0.021 ms	0.63 ms	0.34 ms
IPv6 host	0.25 ms	0.63 ms	0.33 ms
IPv6 net	0.25 ms	0.50 ms	0.26 ms

- KUPF is slower than ALTQ.
- Difference of IPv6 is smaller than IPv4
- The reason is that:
  - » KUPF uses liner search.
  - » KUPF is implemented based on abstracted model.
  - » Procedure for KUPF is separated into two stages.

Future Works

- Performance improvement
  - » Searching records is difficult.
    - – multi-parameters, prefix match, wild card
  - » Two stages cooperation may be effective.
- Other examples
  - » Inspection for conflict of rules
- Development of expression for filter representation

Conclusion

- We proposed 2-phase selection model of classification records.
- We implemented KUPF as a framework of the parameter filter.
  - » adaptable to complicated rules
  - » flexible filter rules
  - » expansible filter rules, independent of service
- In future works, we need performance improvement and other applied example.

More Information

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- KUMA Project
  - » http://www.kuma-project.net/