Interpreted Active Packets for Ephemeral State Processing Routers

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7th International Working Conference on Active and Programmable Networks

Outline

You Said "Ephemeral State Processing" ?

cf. *Lightweight Network Support for Scalable End-to-End Services*, Kenneth L. Calvert et al., SIGCOMM 2002

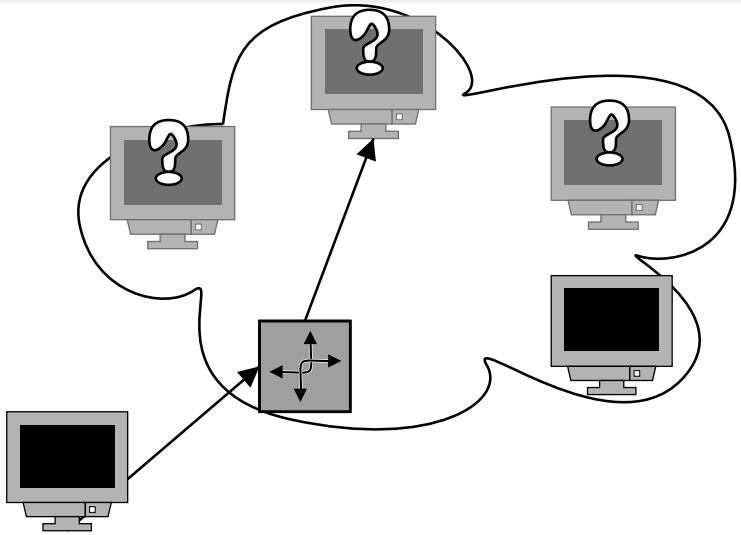
A minimalist active service based on *ephemeral state stores*:

- memory slots on routers with key-based access
- values stored for 10 sec., no refresh.
- ESP defines *operations* on those slots.
- tells if packet is forwarded or dropped.

⇒ Applications in topology discovery, flow aggregation, multicast...

⇒ Can fit network processors such as IXP1200 or IXP2400

Ephemeral State Could Store Much More !



Potential Applications

1. locate “volatile” peers
2. MPEG smart dropping
3. track mobile hosts

Missing Features

- store IP addresses in tags
- early packet return
- interface state inspection
- packet rerouting from tags

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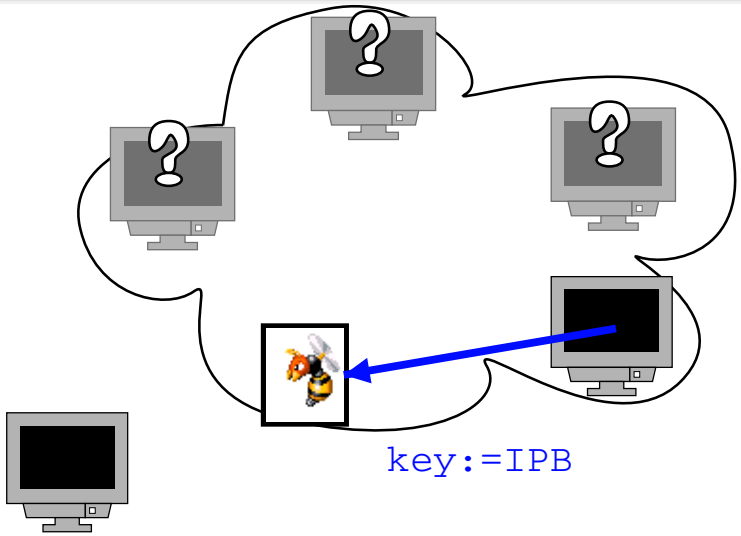

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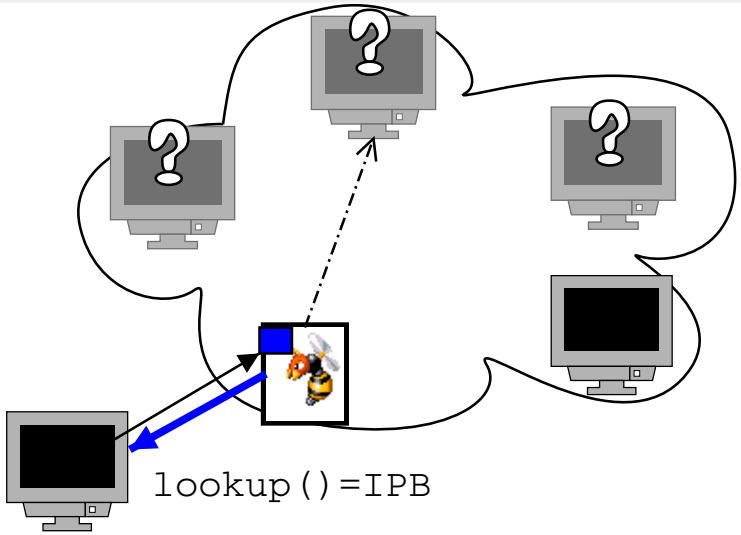

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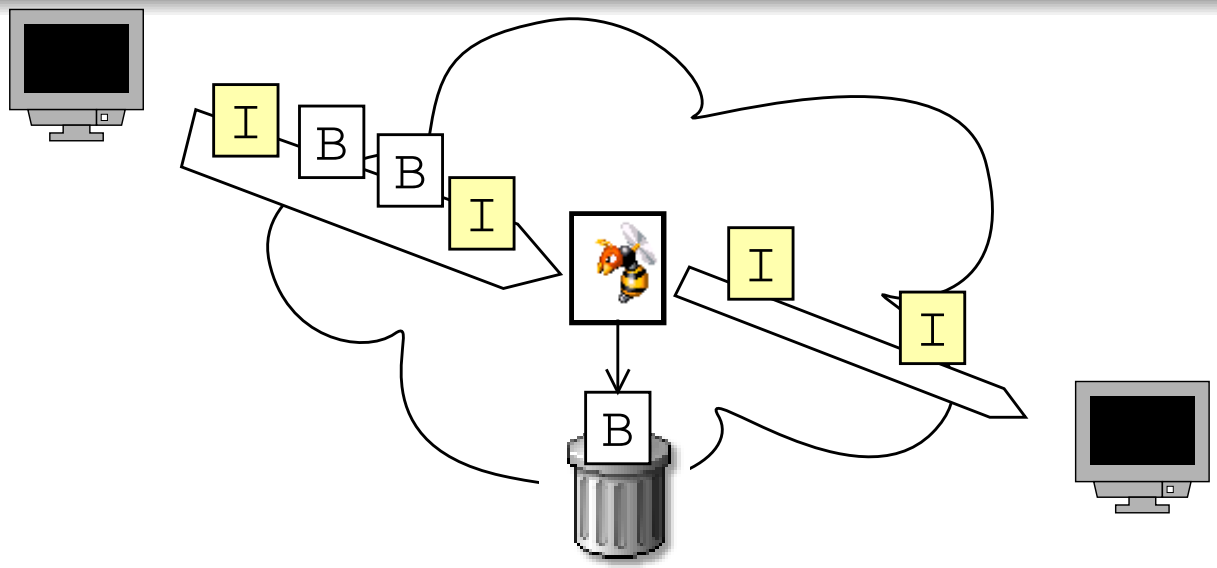

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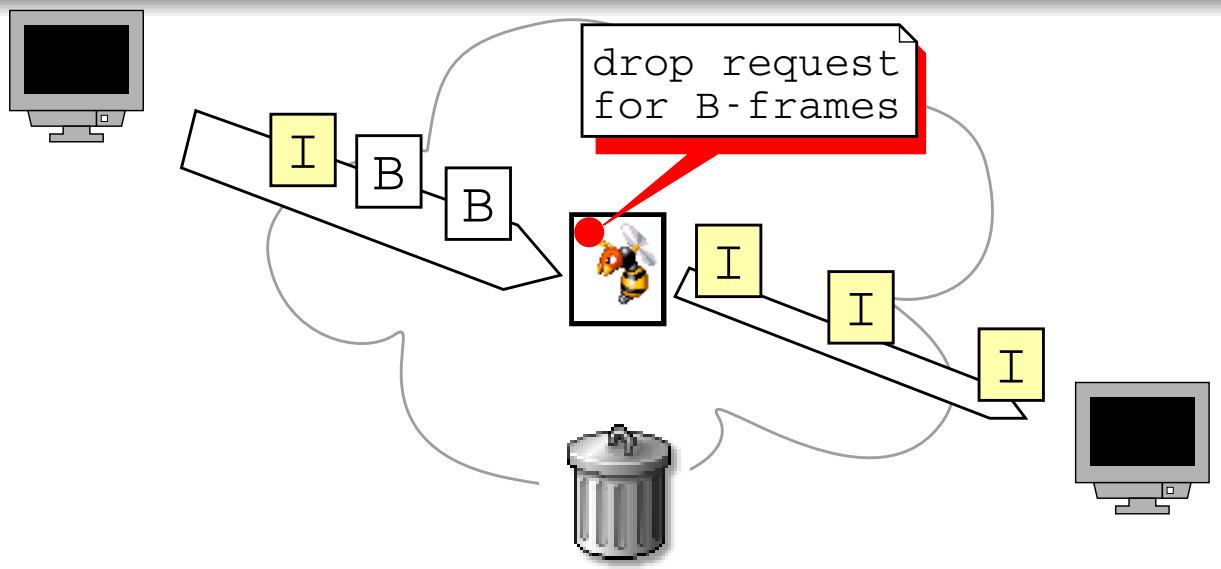

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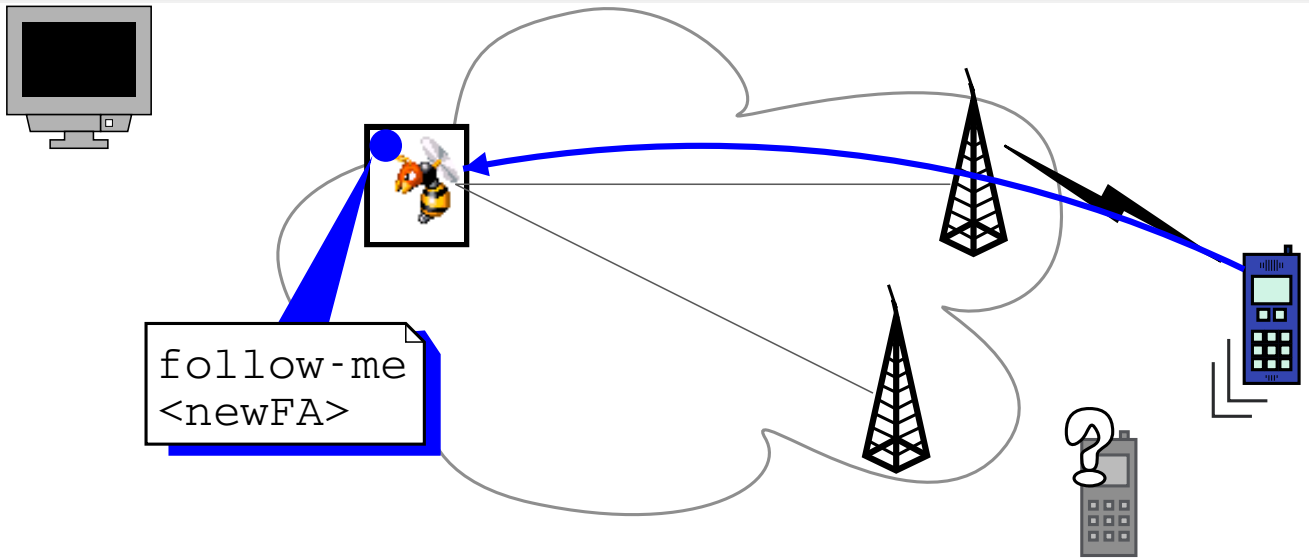

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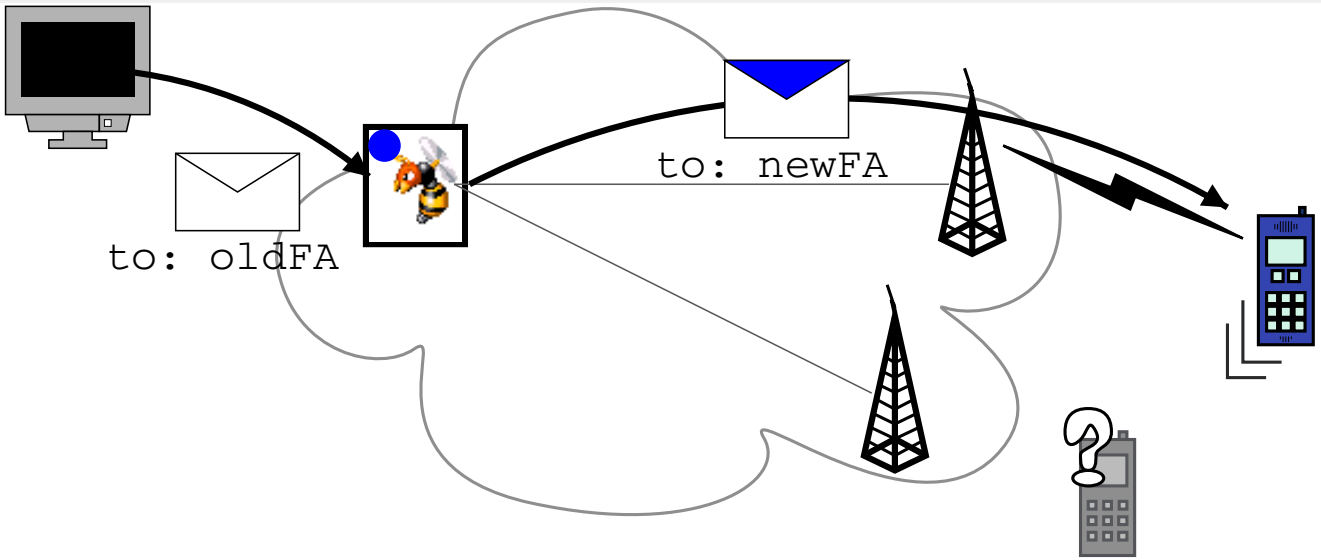

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Extending ESP Instruction Set

Beyond 'missing features', ESP only support very few operations ...

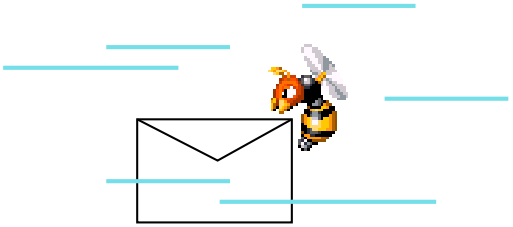
- little space for more ESP code on IXP microengine
- unconvenient to reprogram on the fly (no JIT)

Can we manage to interprete bytecode carried in packets ...

- with comparable packet processing time ?
- without putting the router at risk ?
- and store the interpreter on a microengine ?

World-Friendly Active Packets for ESP

Safe and efficient framework, for both end-user and network operators



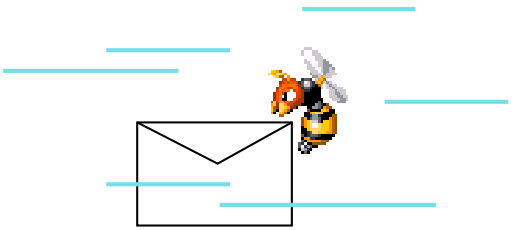
Router-Friendly do not waste resources

Network-Friendly behave like IP packets

User-Friendly don’t perform unexpected actions

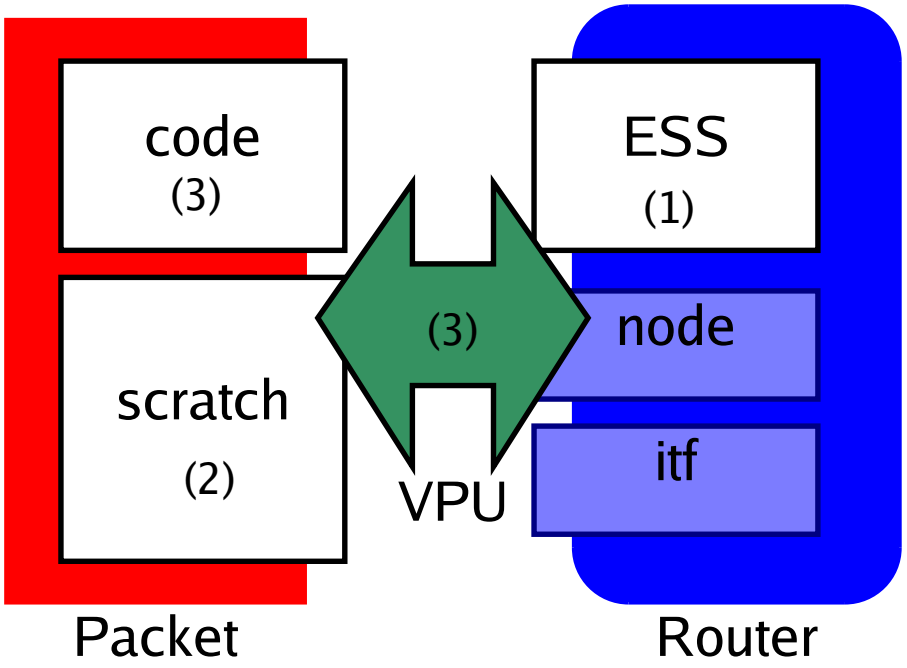
World-Friendly Active Packets for ESP

Limited, yet useful programmability



- small programmable control protocols
- programmable packet control embedded in datapackets
- discover network topology, user communities, services

Inside WASP: The Virtual Processing Unit



1. lookup/insert into **ESS**
2. load/store data from packet's scratchpad
3. interpreted, RISC-inspired packet bytecode
4. control opcodes (drop, forward, return)

- tiny interpreter code (4K)
- data and code used 'as is' (no marshalling)
- simple ALU design and compact opcodes

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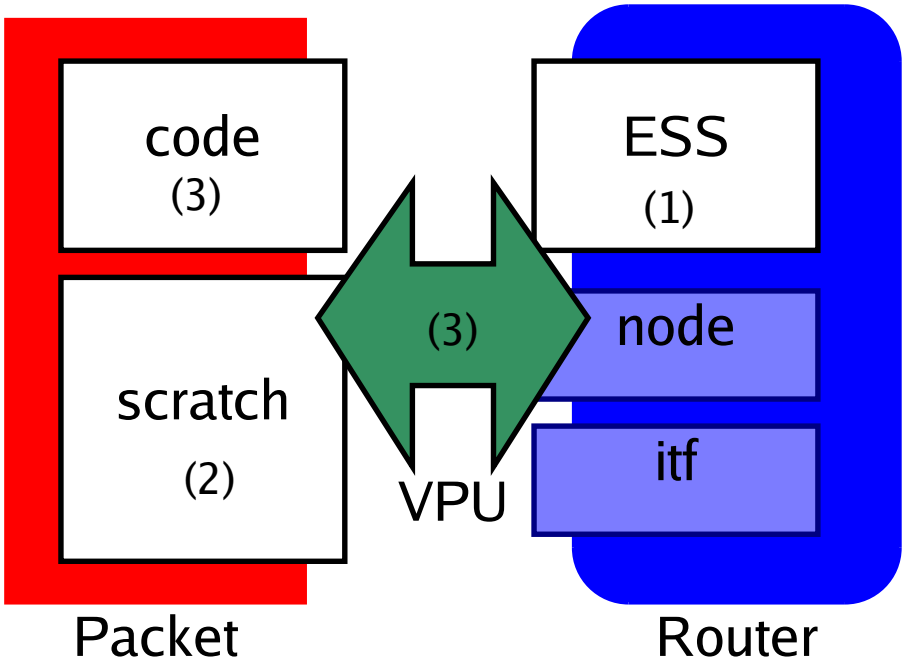

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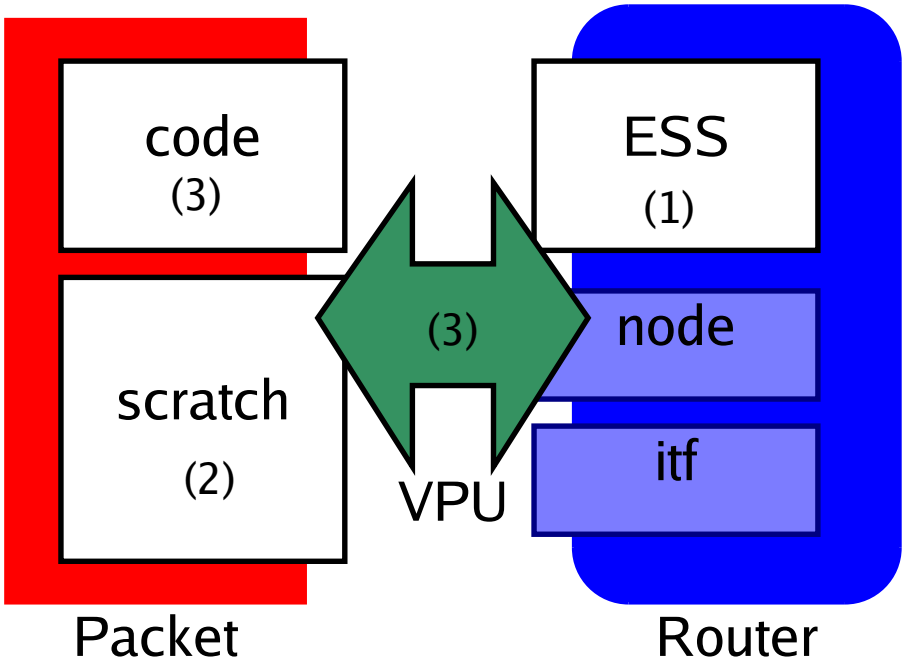

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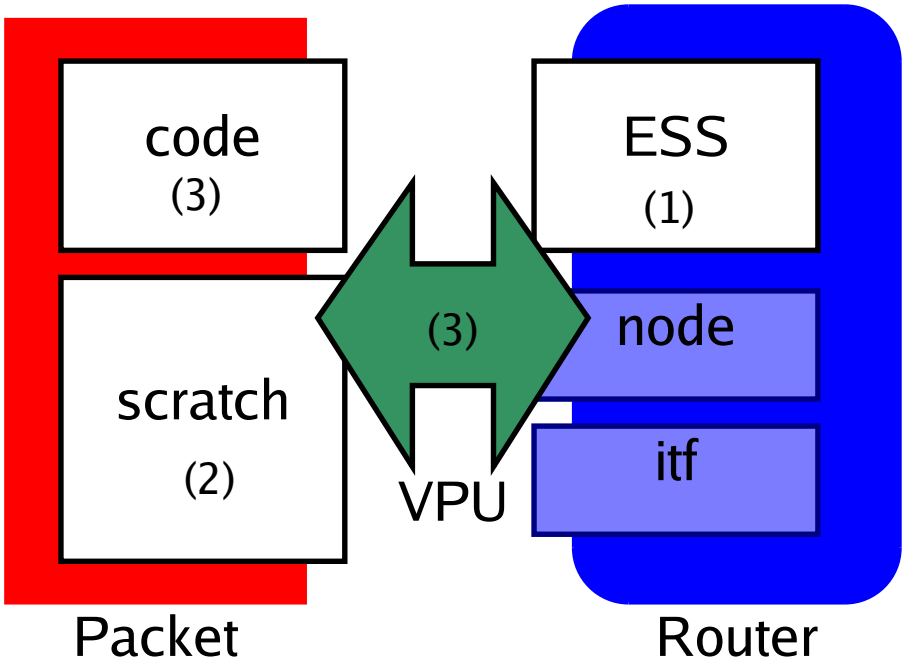

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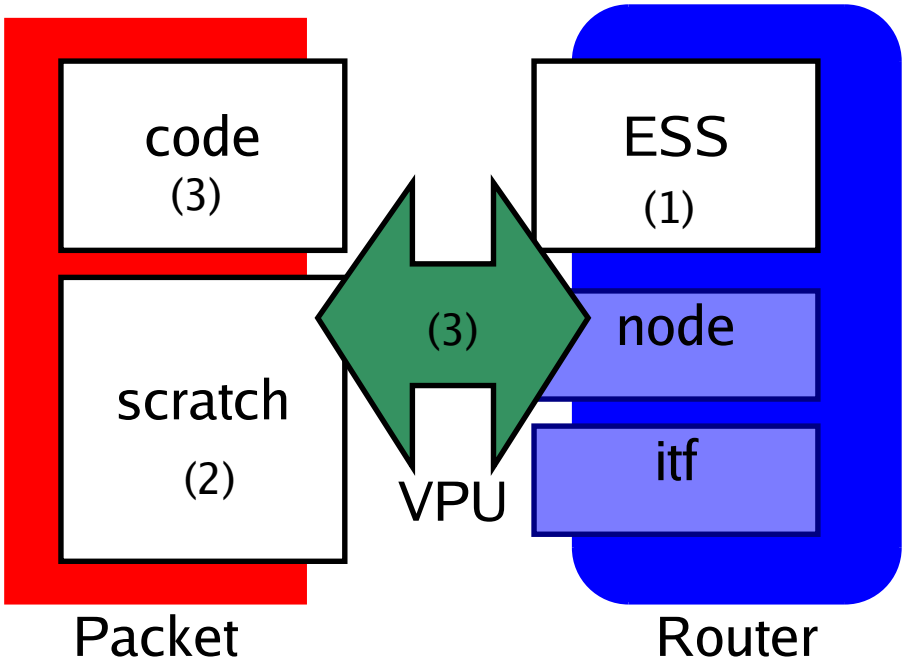

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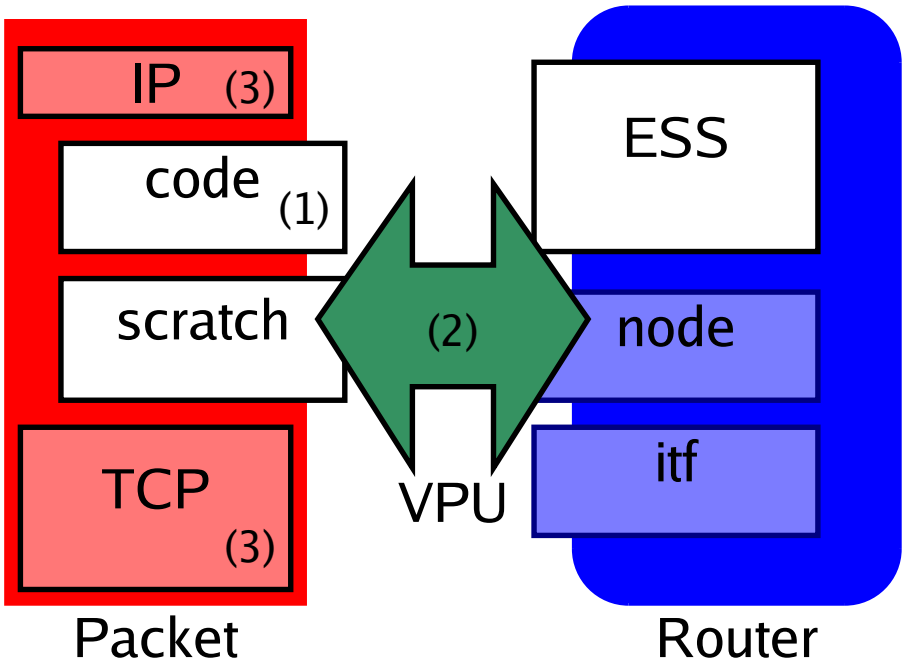
WASP is Safe!

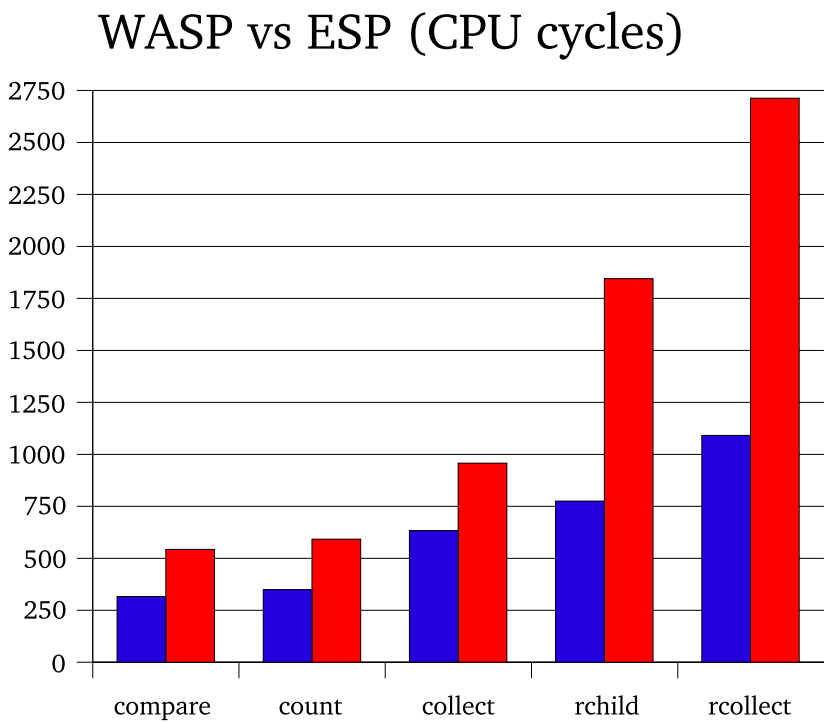
cf. *Practical Active Packets, Jonathan T. Moore*, University of Pennsylvania

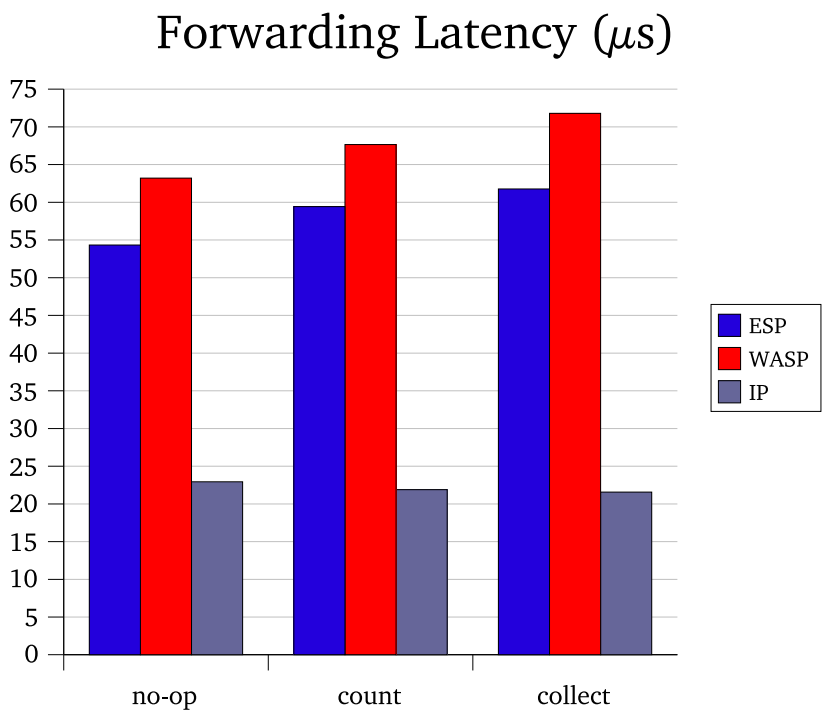


1. no backward jumps
2. no heavy computation
3. transparent to other protocols
4. no packets cloning

So WASP is inherently router-friendly.

VPU Performance

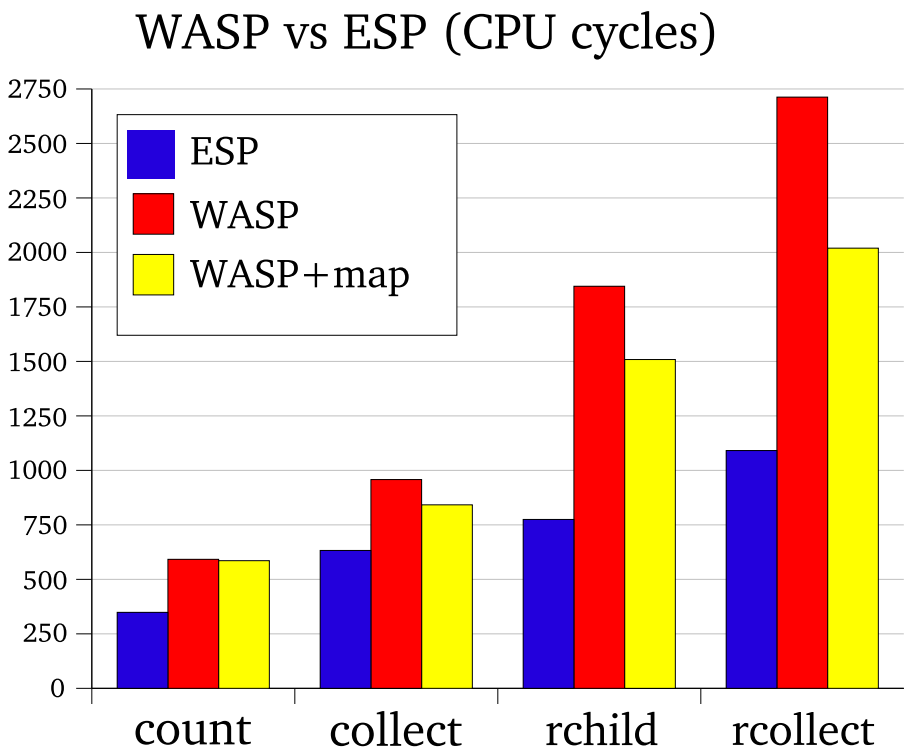




- benchmark on a Pentium Linux router.
- interpretation takes 150% to 250% of native execution time
- only a small part of packet latency (115% overhead)

Mapping Larger Tags for Better Performance

Preformance Improvement



- single key contain all service state
- smaller packets (fewer keys needed)
- faster processing (185% of ESP)

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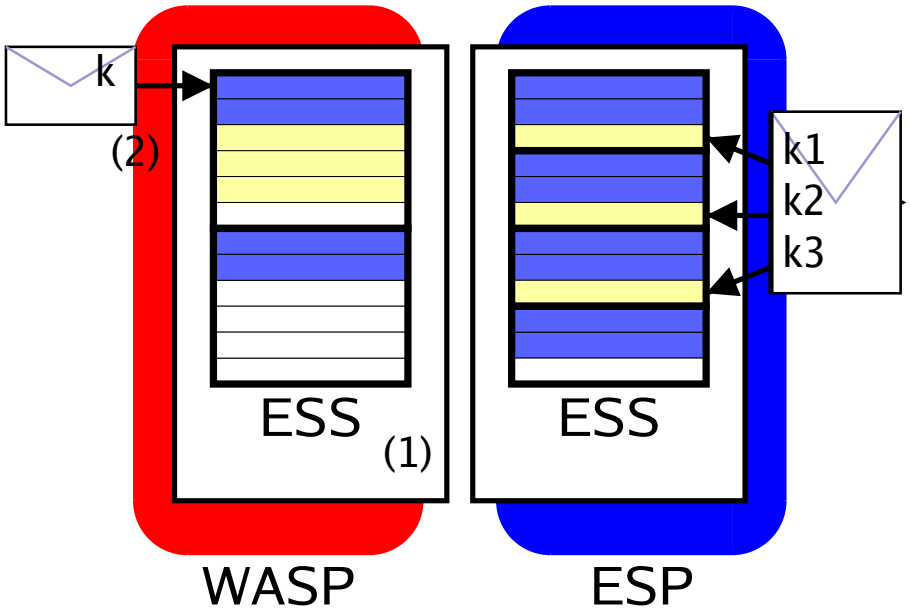
How It Works



- size up ESS entries to 32 bytes
- lookup ESS only once
- load/store to mapped copy
- write back when done

- good performance expected on IXP (SDRAM latency)
- no memory overhead if at least 2 words per state

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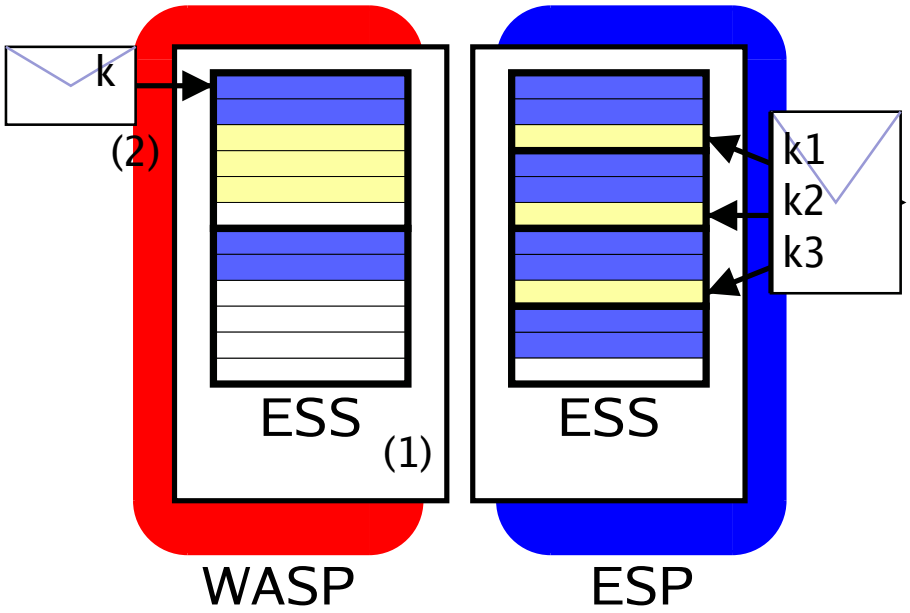

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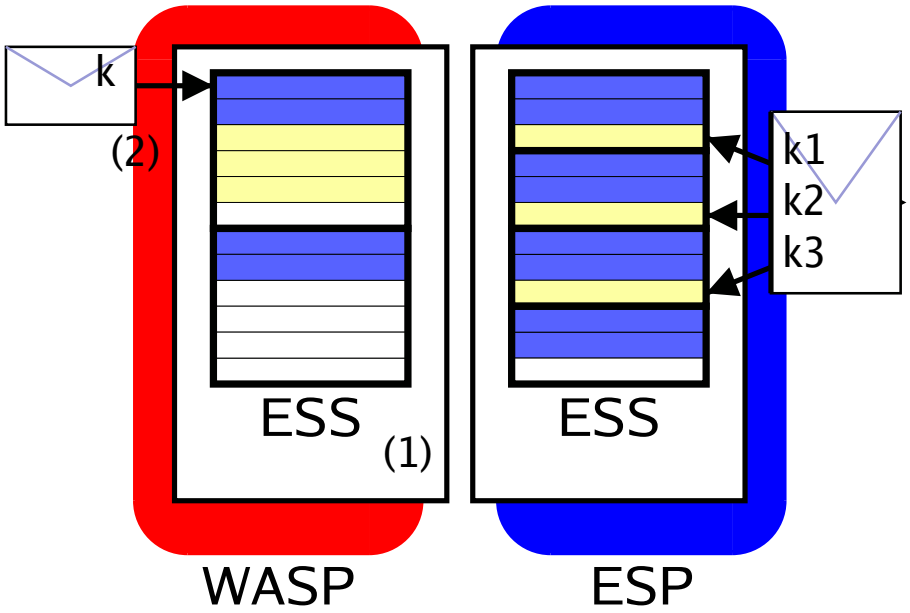

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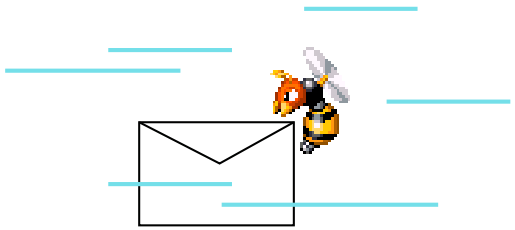
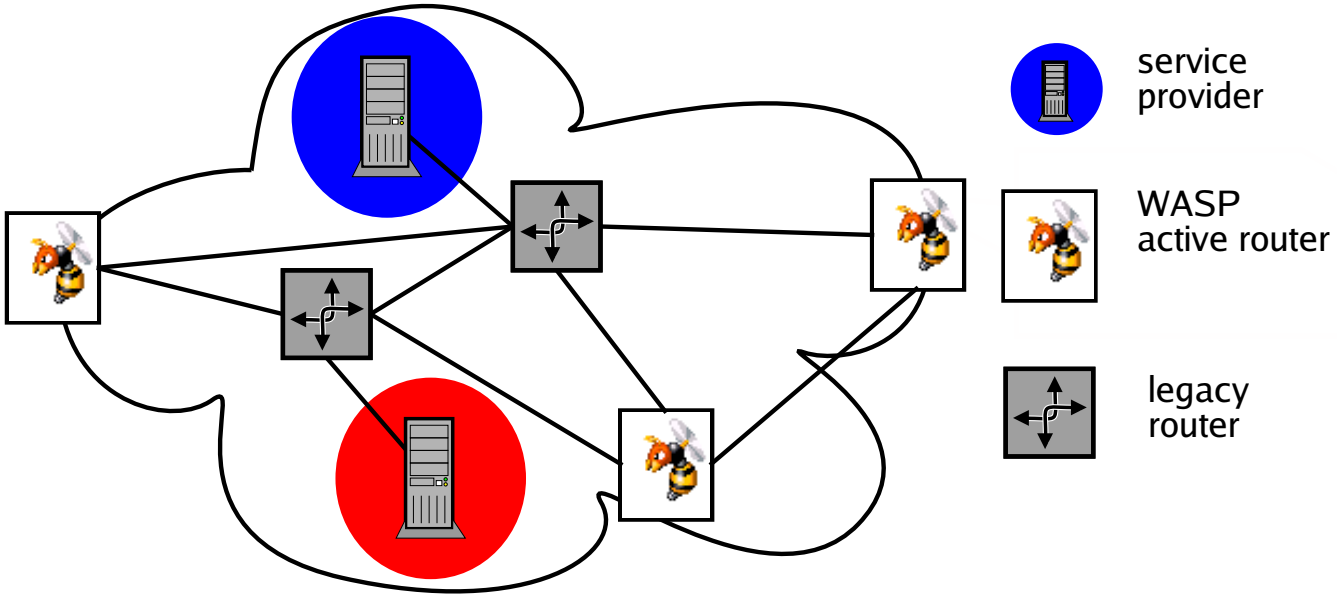
Discovering Services with WASP



How can WASP help for more complex services ?

MagNet (1): Advertise Service Within the Domain.



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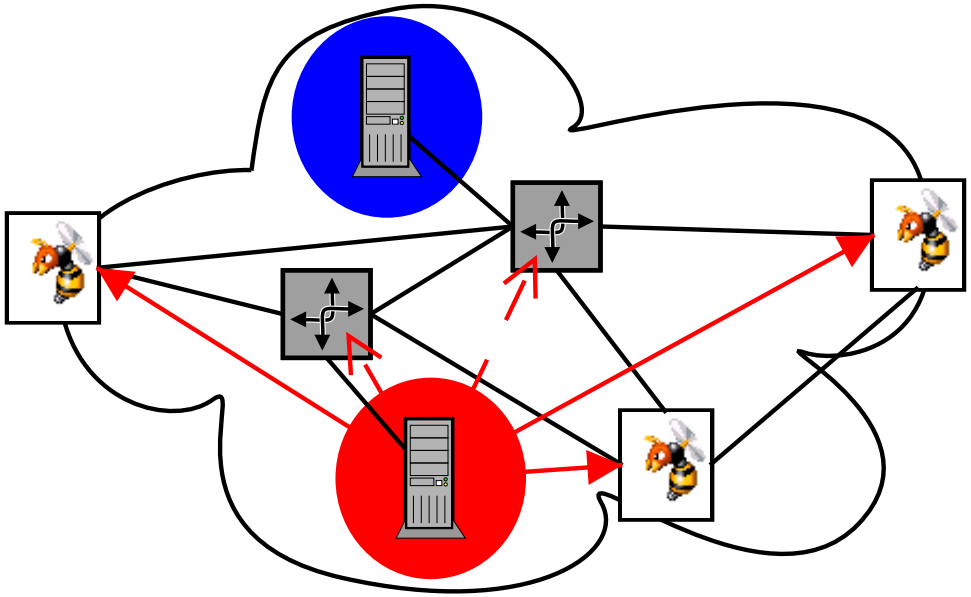

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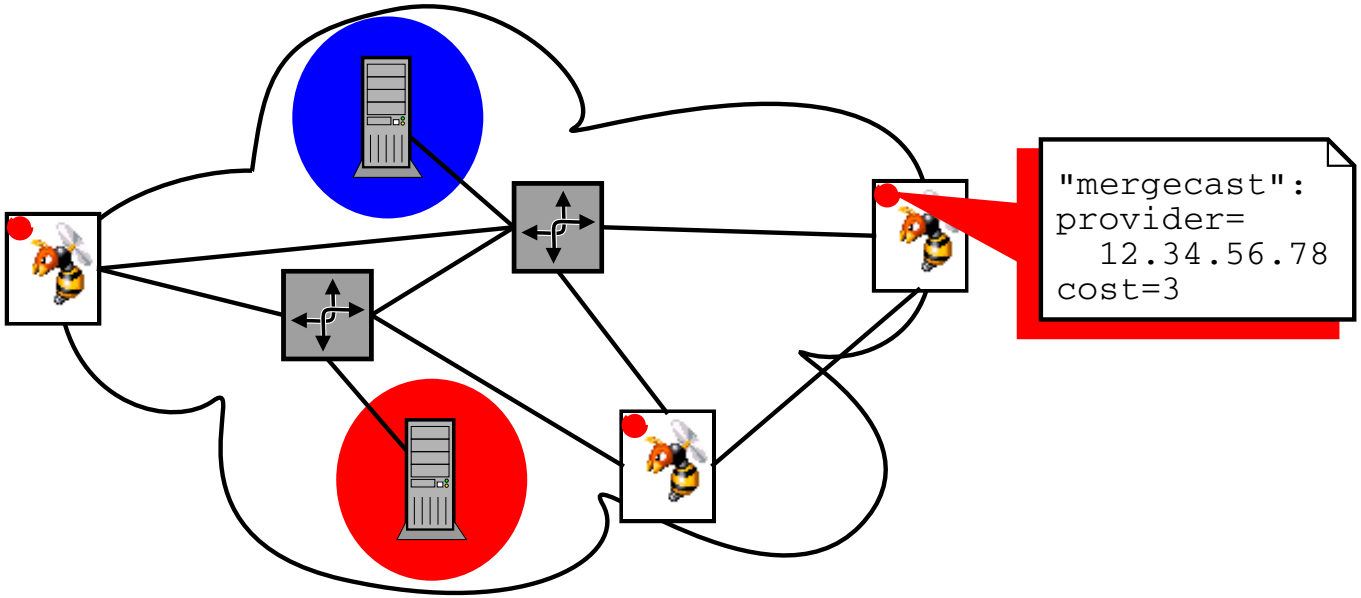

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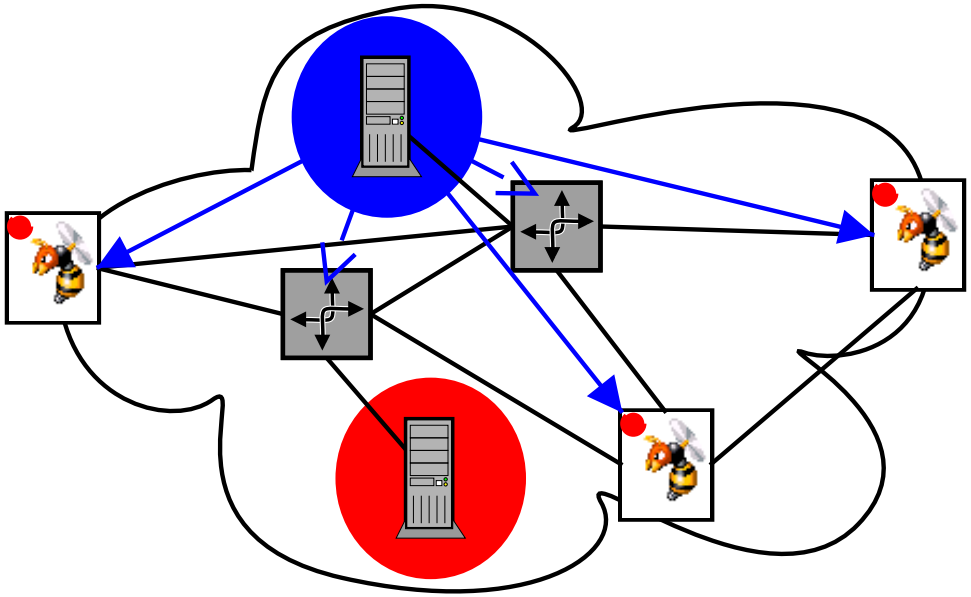

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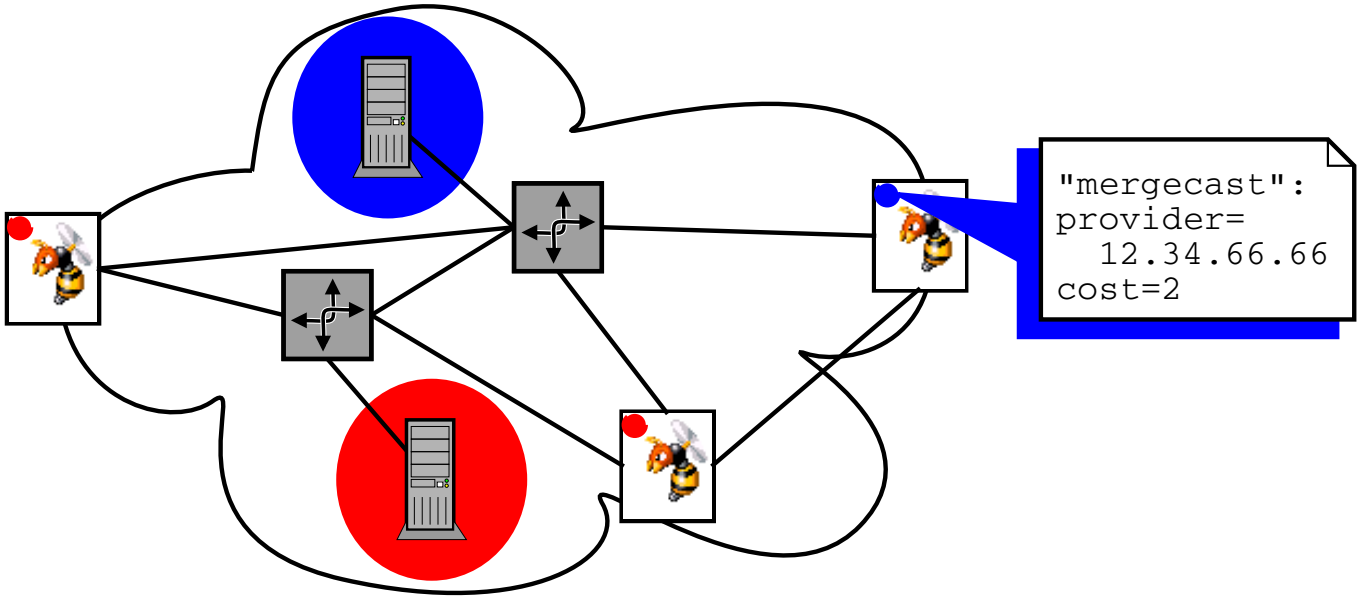

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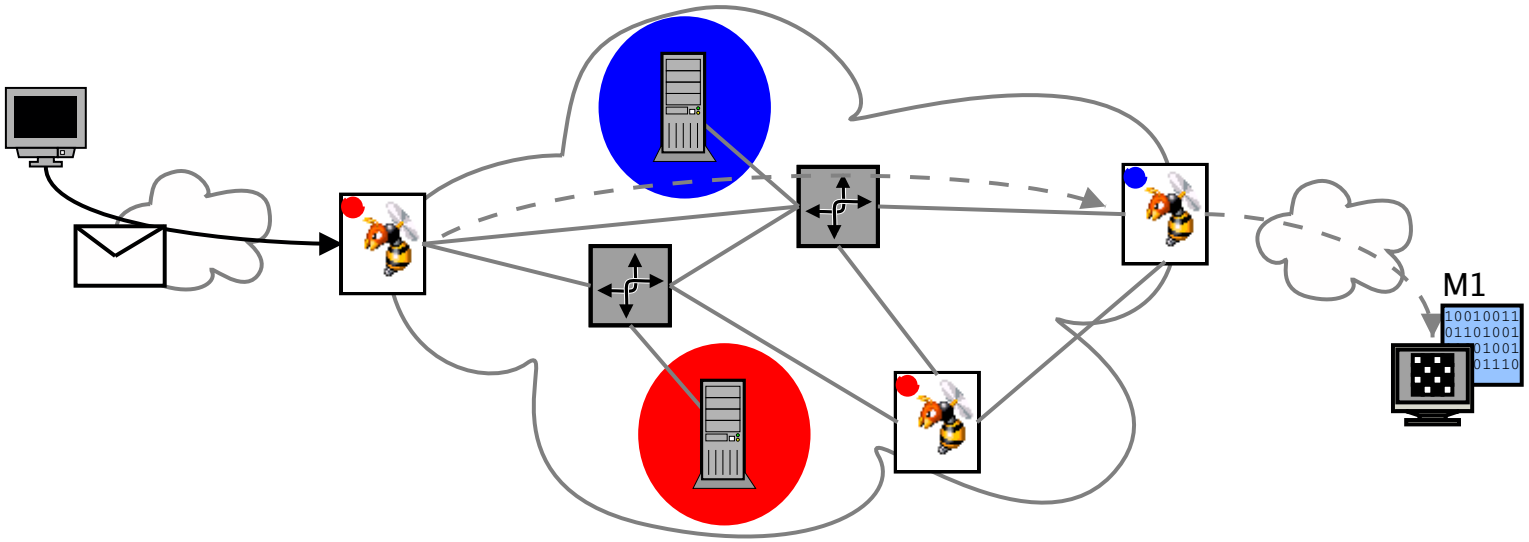

- send a connection request to retrieve results
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- then let the packet go and store more addresses
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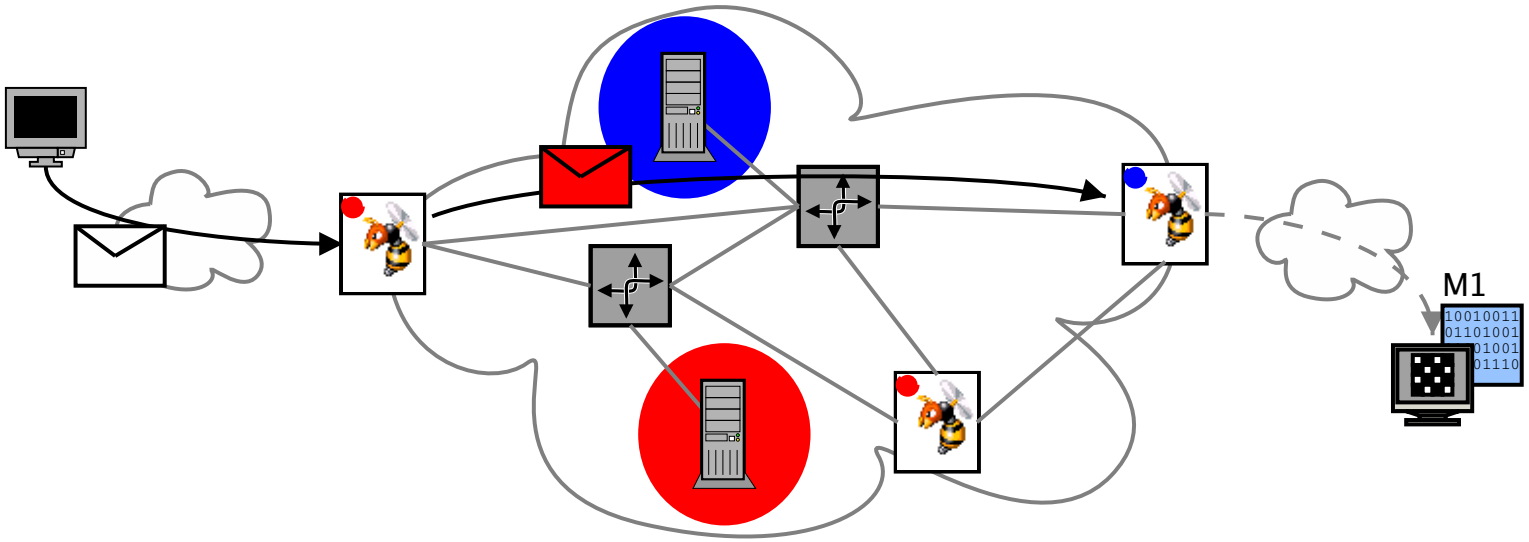

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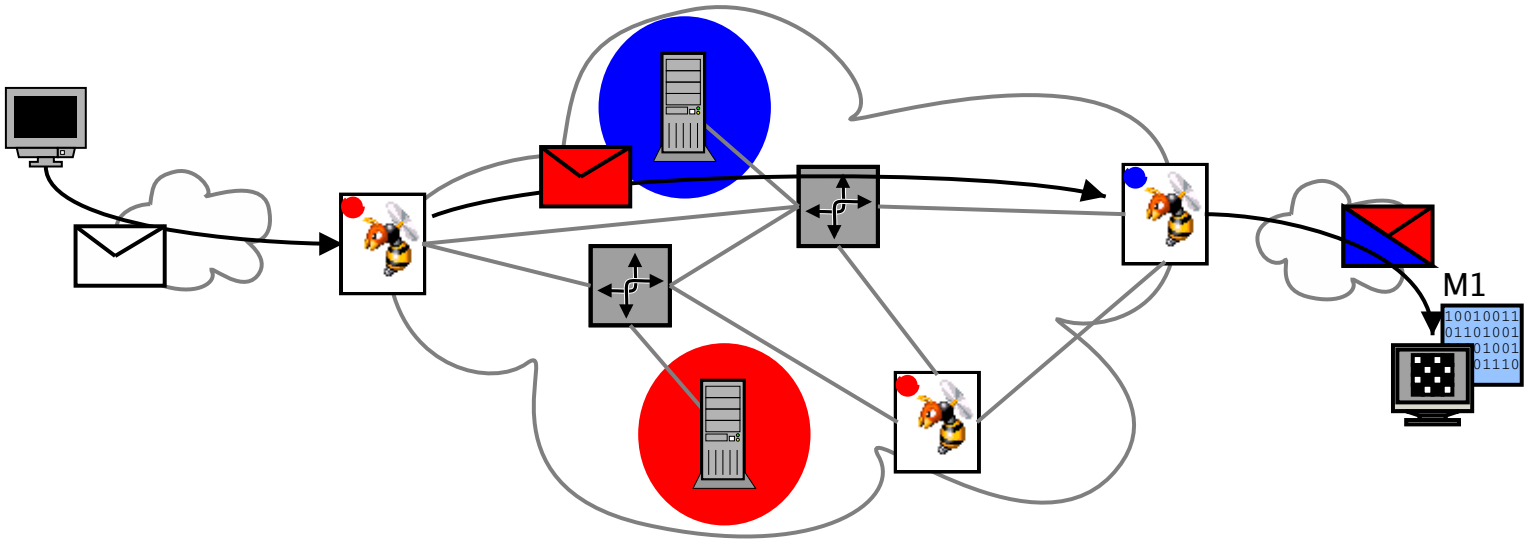

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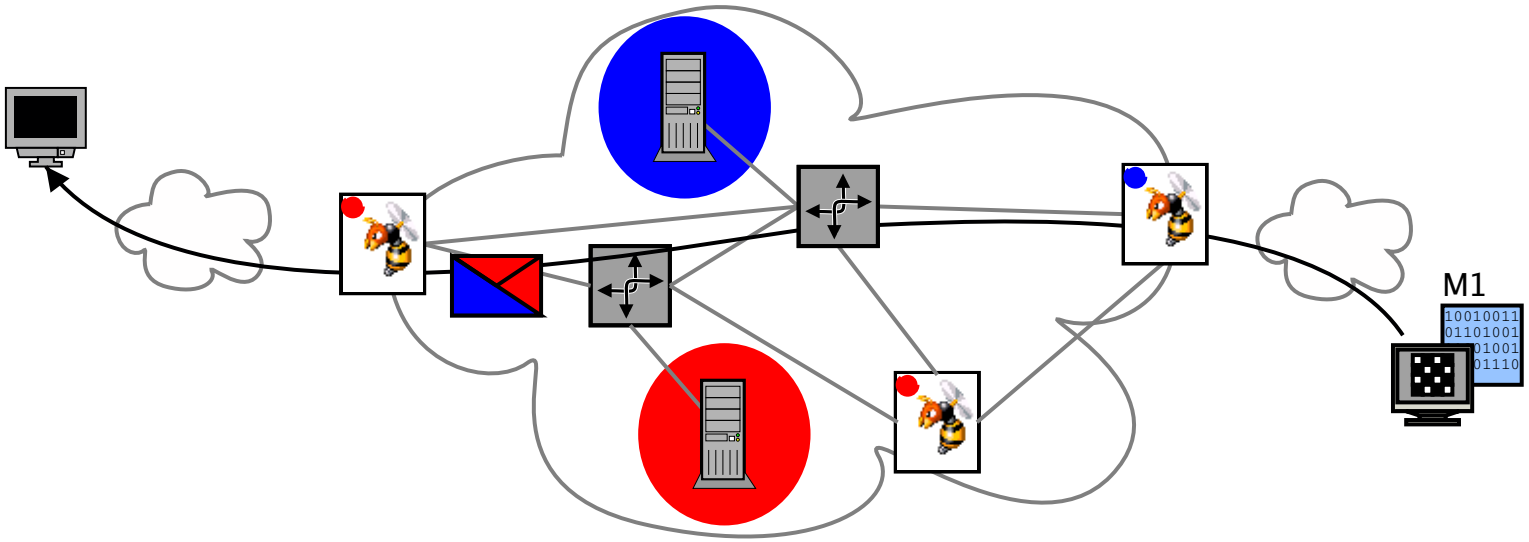

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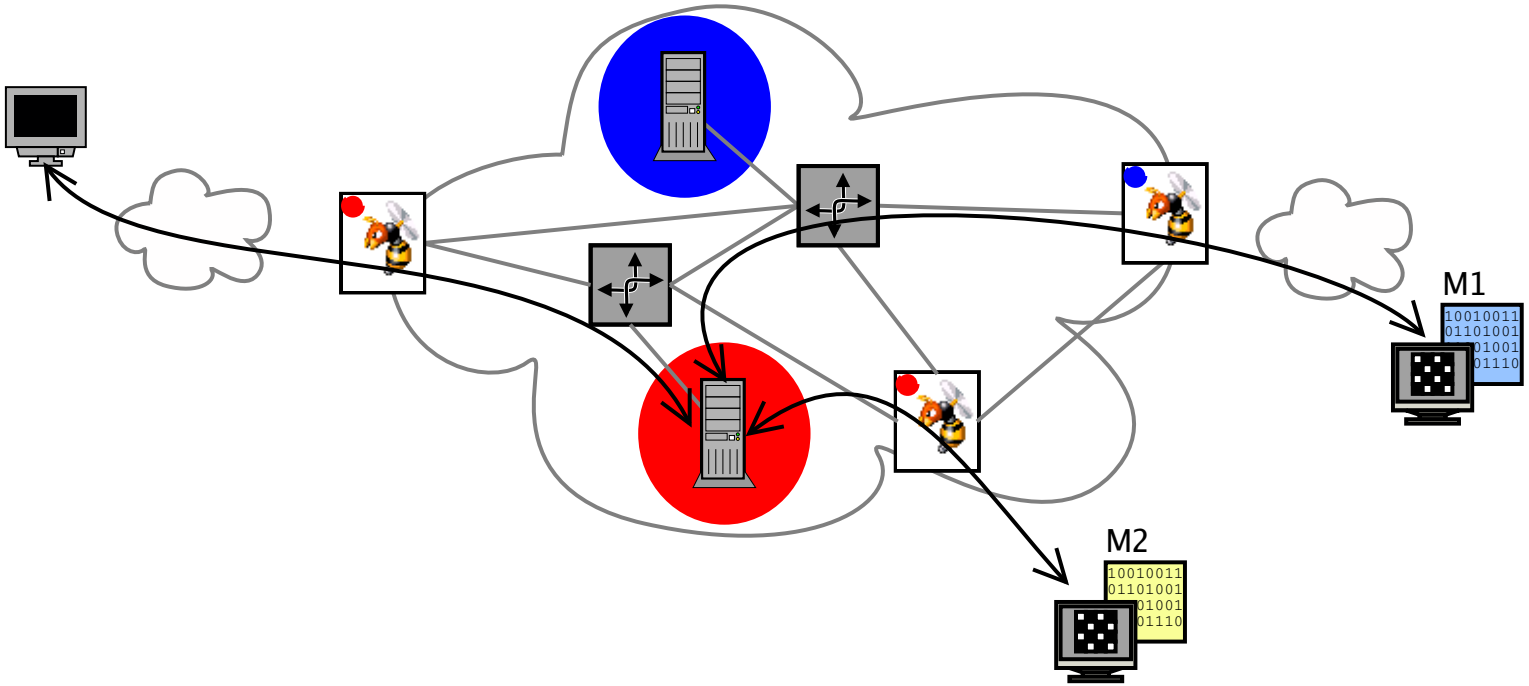
Finally Use The Service.



Client can gather all information required to set up the preferred service provider(s).

Extending Storage Semantics

WASP divides keys space for extended tag semantics:

- **public** assume all keys are random and world-writable (default)
- **protected** only operator can write, anyone can read.
- **private** key is generated by hashing bytecode tag cannot be accessed otherwise.

Well-known protected keys are required for services discovery.

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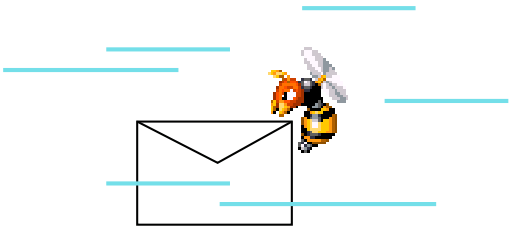
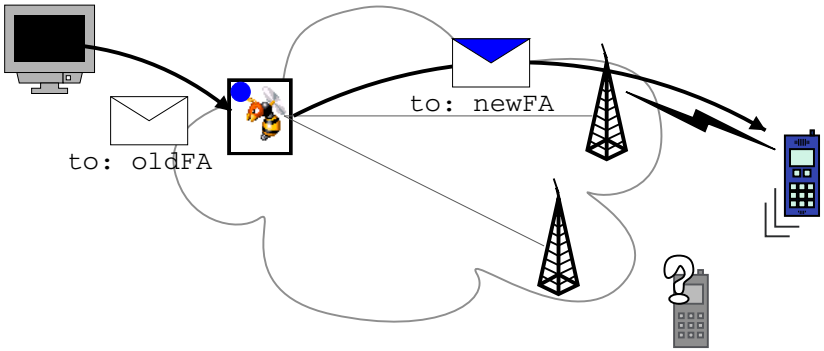
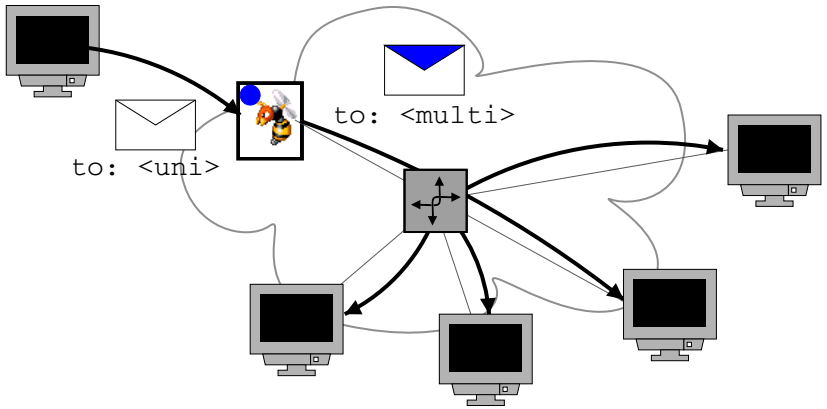


What about changing destination address on the fly ?

World-Friendly Rerouting (?)





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- useful for real-time multimedia
- hybrid multicast/unicast routes

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- looping packets ?
- billing ?
- who gets my packets ??

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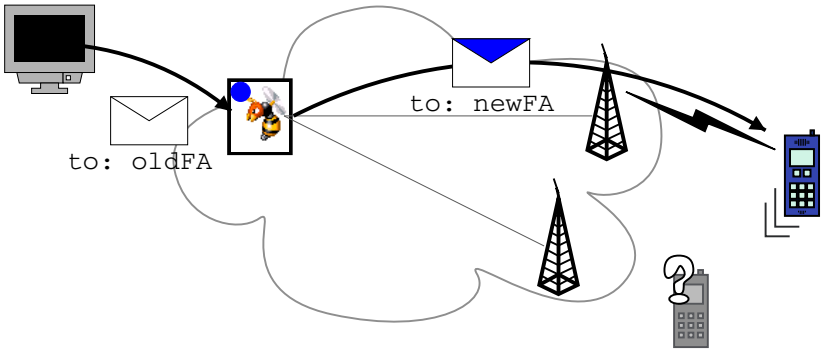

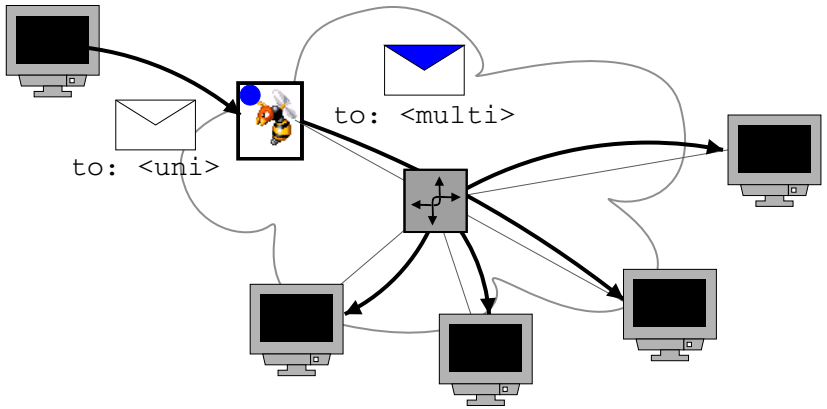

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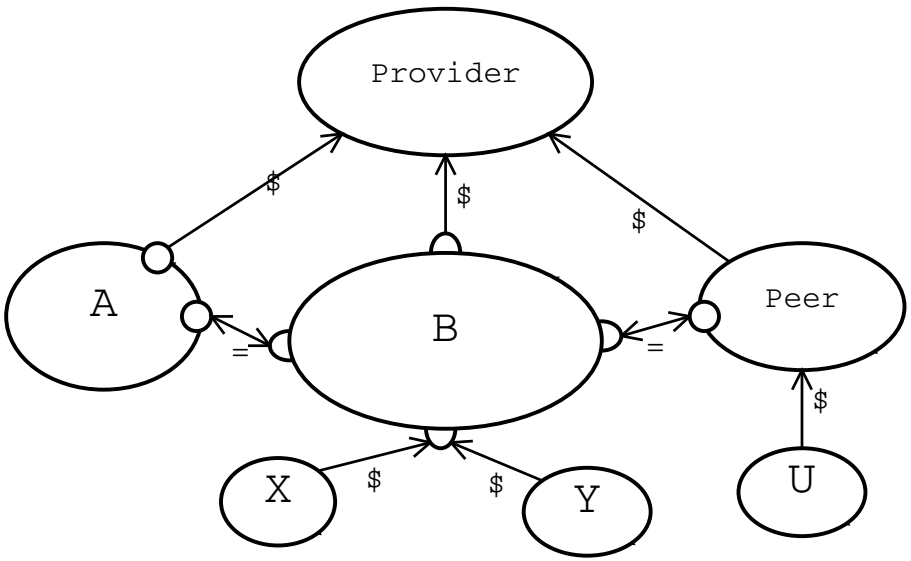

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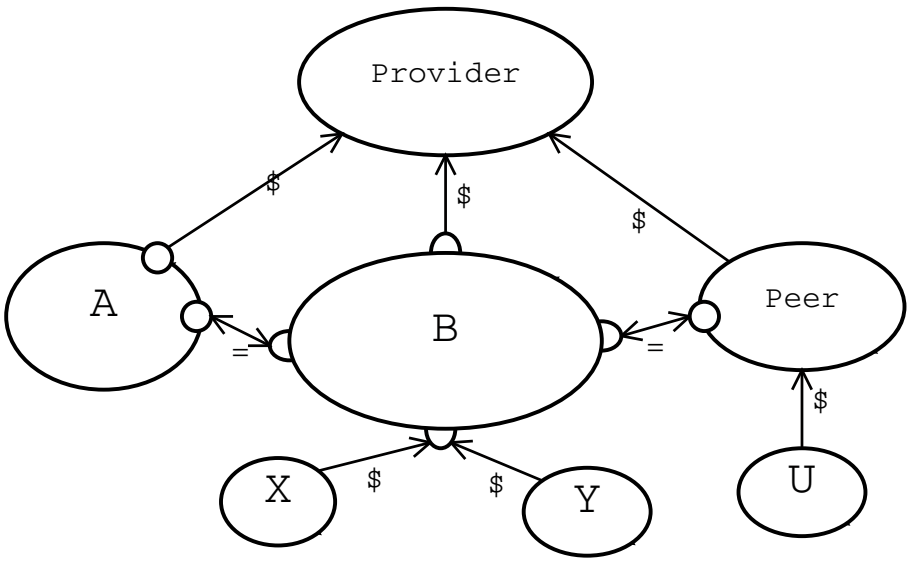

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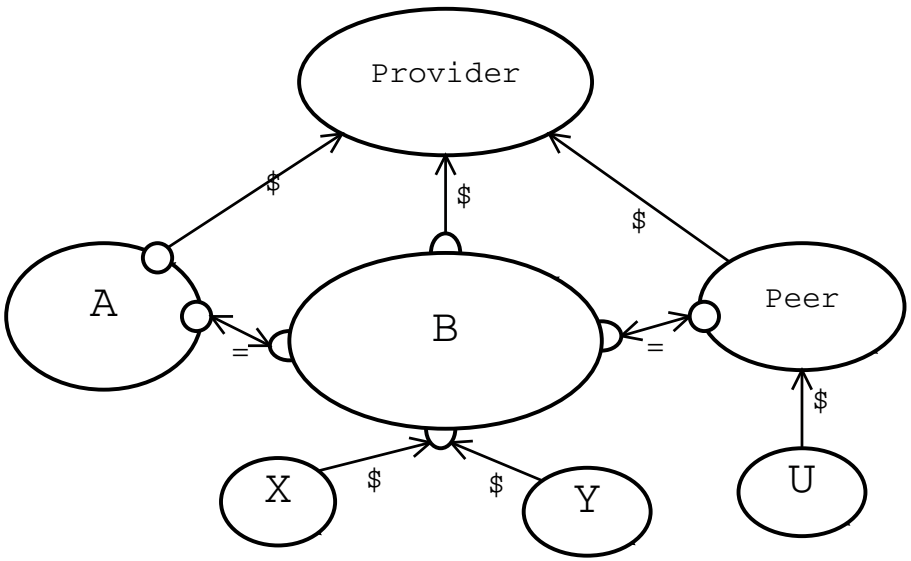

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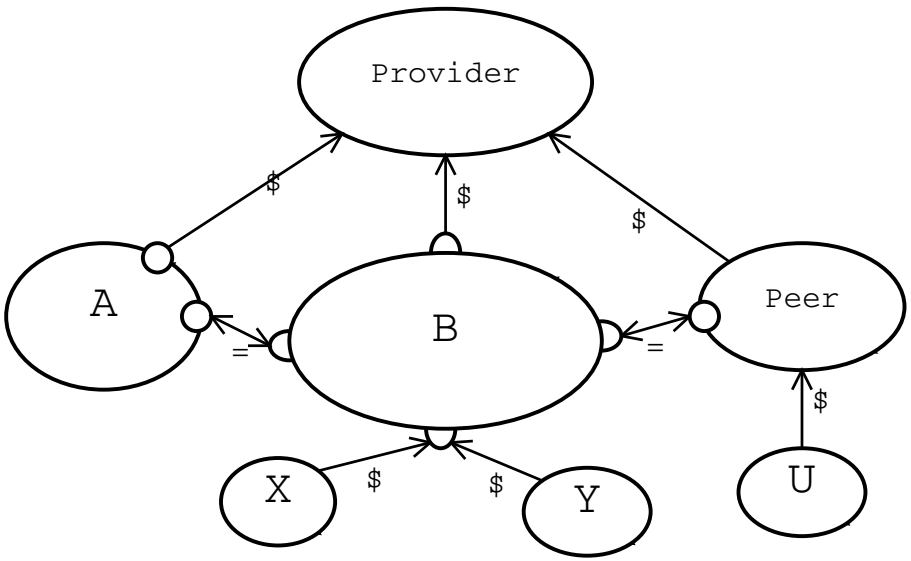
2. At egress, ensure new address goes through same interface
3. Ensure guest packets can be rerouted only to clients

Interdomain Rerouting Made Friendly



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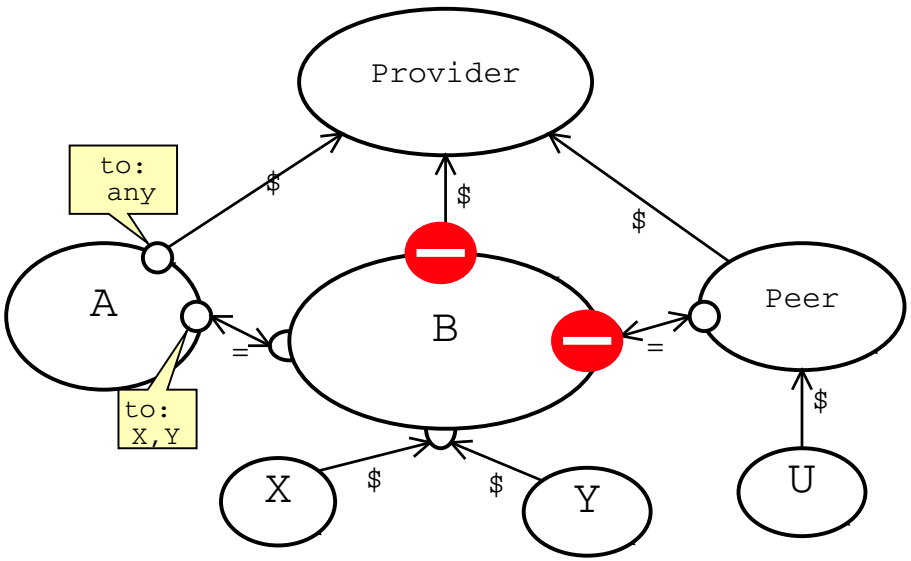

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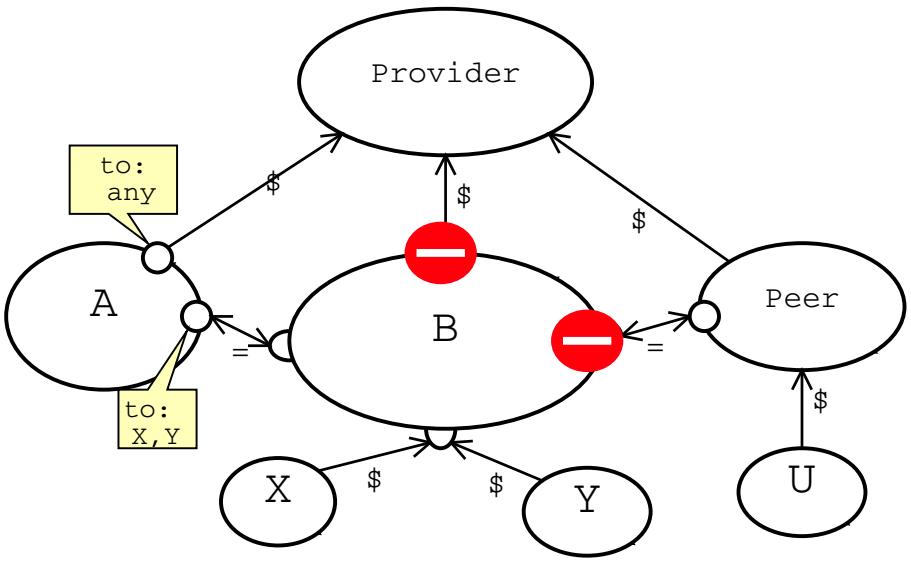

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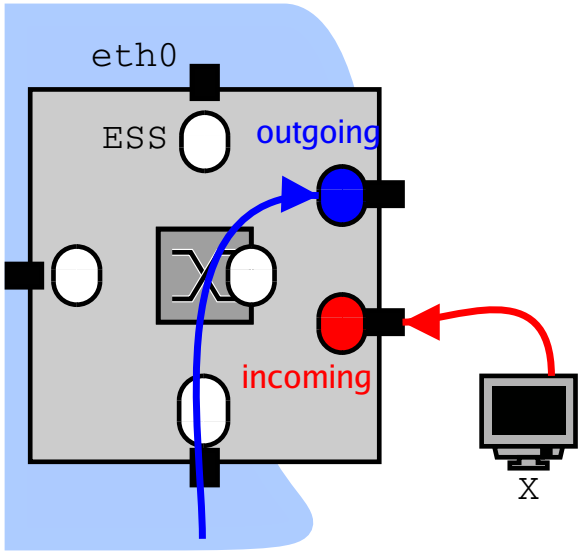
Rerouting With Invitations



- `invite` store packet source in ESS
- key used can be created only with `invite`
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⇒ no packet turnback

⇒ no packet sent on wrong interface

⇒ loop-free if guest packets invite at ingress only.

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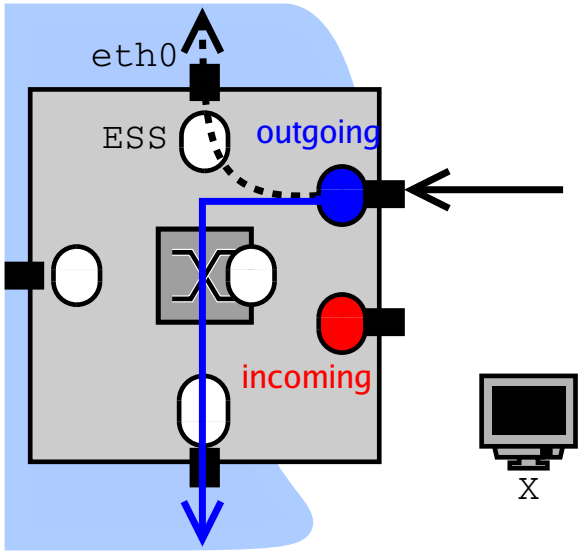

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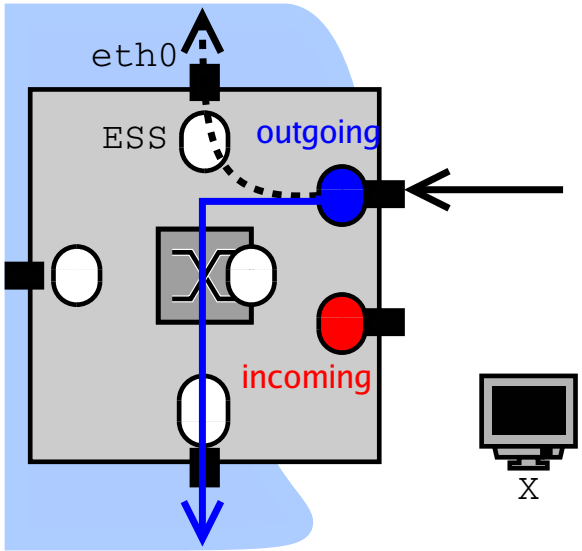

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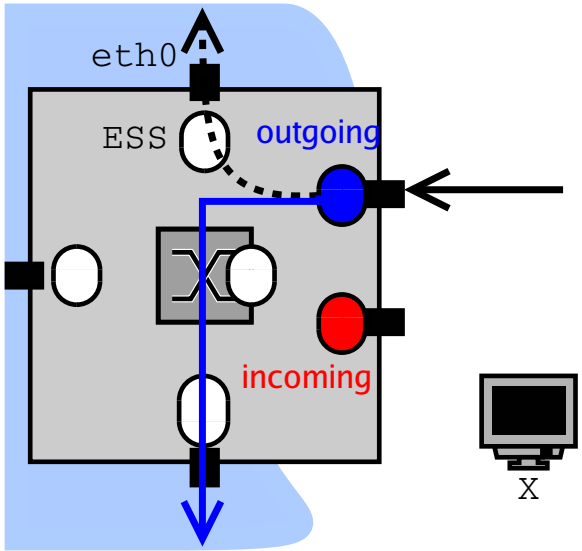

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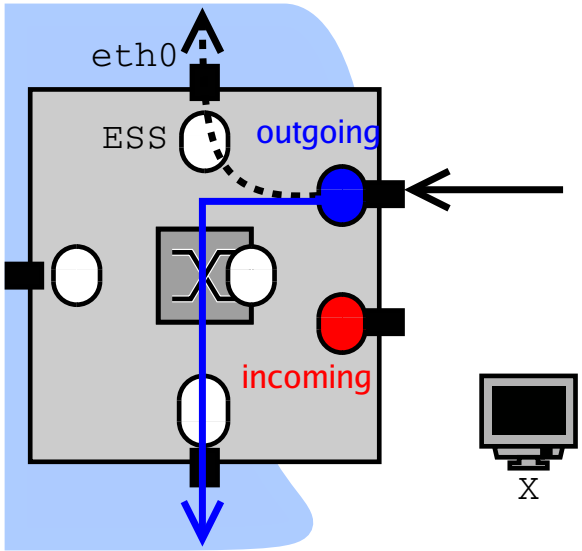

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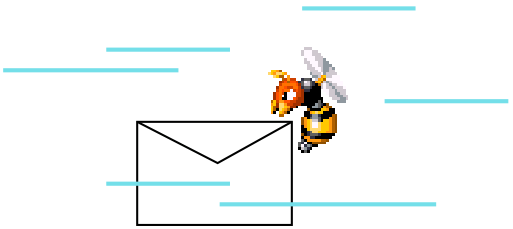
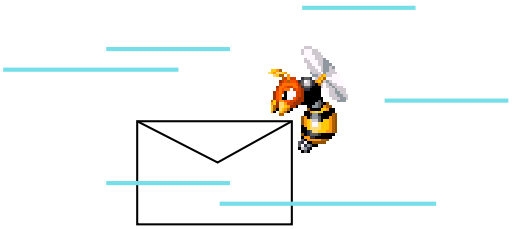
Conclusions

- Ephemeral State could do more than ESP
- WASP can build simple solutions based on ESS
- Discovery for more complex solutions
- good performance on Pentium
- good hope to be ported to IXP
- Rerouting still needs investigations (DDoS tracking, users' privacy ...)



Questions ?



Anyone ?

Outline

Not Any Packet Can Go Anywhere