NUTSS: An End-Middle-End Approach to Connection Establishment

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End-Middle-End: Why?

Originally, Internet supposed to provide:

1. User-friendly naming of hosts (DNS)
2. Network level identification of hosts (IP address) and best-effort delivery
3. Identification of application on host (port)

End-Middle-End: Why?

Implicit assumption:

- Application can defend itself.
  Competent to look inside packet.
- Wrong. (DoS, software bugs, . . .)
- Resulted in firewalls
  - Compromised end-only control
  - Cannot identify application. Or hosts behind NAT.
  - Resort to deep-packet inspection
  - Endhost unaware
- Made network brittle
- Often legitimate connections fail!!!

End-Middle-End: Why?

Required additional Internet services

4. Block unwanted packets before they reach application
5. Explicit negotiation of middlebox usage.
    - Need not be on data path

End-Middle-End

These services, along with original three, represent the minimum requirements for the Internet.

NUTSS

NUTSS is an architecture and protocol that instantiates End-Middle-End

Primary Goal

Allow connection establishment that honors access control policy of all stakeholders (ends and middle).

Also, middlebox steering, host mobility, anycast, redirection, multi-homing, multicast, protocol negotiation

End-Middle-End and End-To-End

- E2E broken by middleboxes
  - Middlebox control in the middle
  - Endpoints oblivious of middle, cannot adapt
- EME exposes functionality in the middle
- Allows ends and middle to cooperate in middlebox control
  - Explicit two-way negotiation between ends and middle
  - firewall policy, NAT ports, protocol stack

Names vs. Identifiers

Names or identifiers?

- Identifiers are scalable, efficient, can be self-certifying BUT not *for* the middle
- Middle needs (user-friendly) names for policy
- Must be aggregatable
  - Identifiers (HIP, i3, DONA) don't allow for this
  - Need additional *reverse* name resolution
- Internet-wide shared namespace

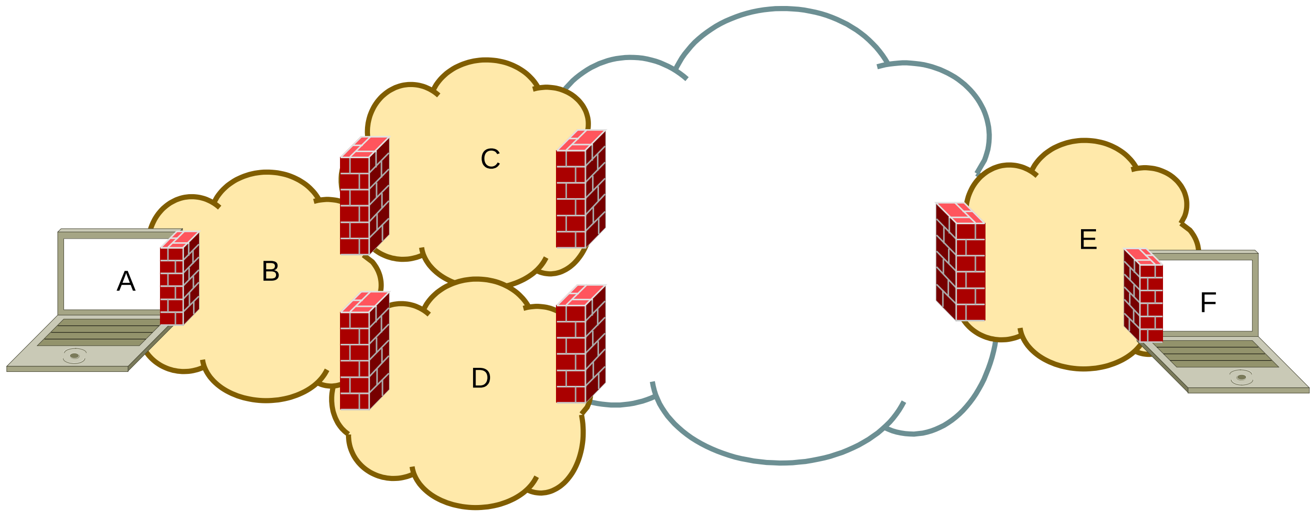
Policy

Where is policy applied?

- On-path (on the data path)
  - Privacy (for address-based paths[1])
  - Constraining (name-resolvers on-path)
  - Intrusive (routers route by name)
- Off-path (separate control plane)
  - Replicate, deploy far from endpoint (DoS, scalability)
  - But data path is address-based

[1] "Identity Trail: Covert Surveillance Using DNS" in PET '07

NUTSS: Big Picture



- Address-routed path, off by default
- Name-routed path, on by default
- Overlay of stakeholders.

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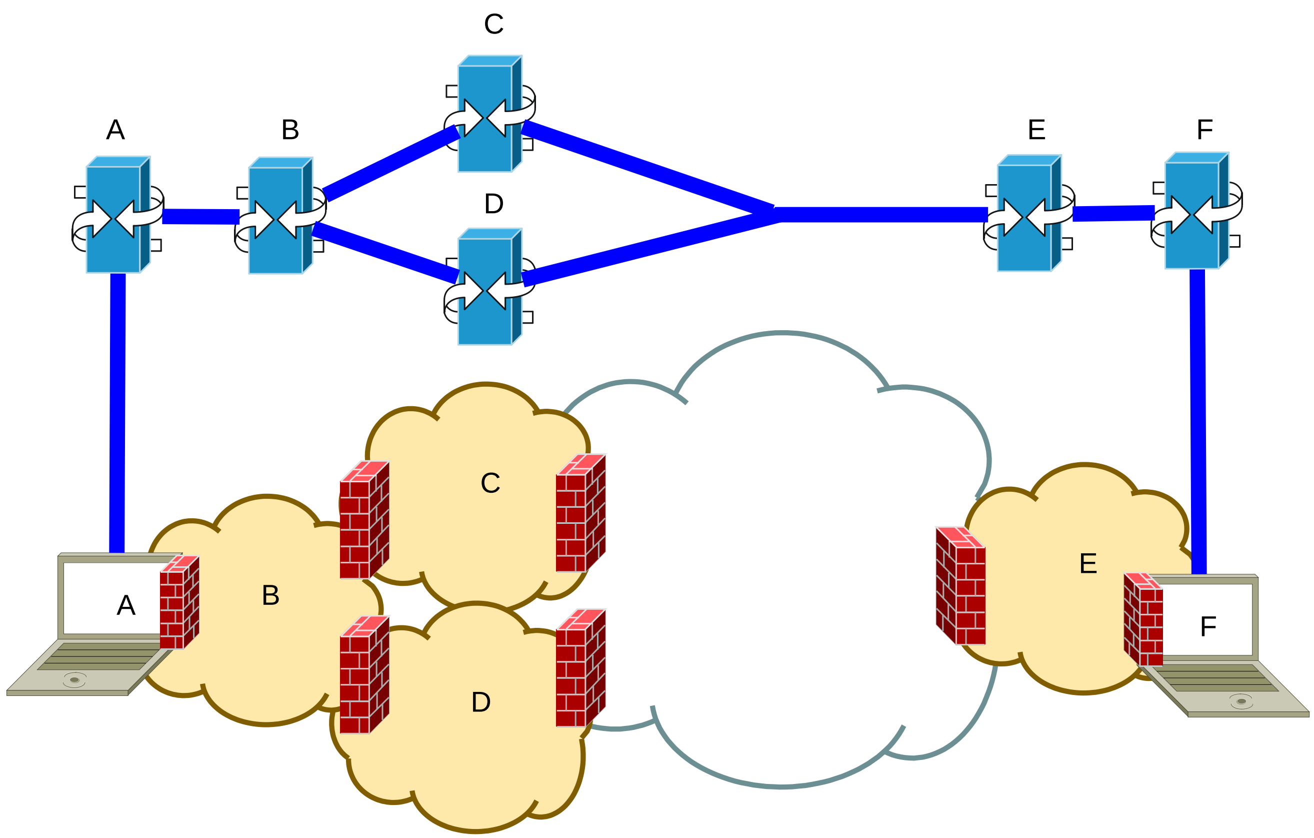

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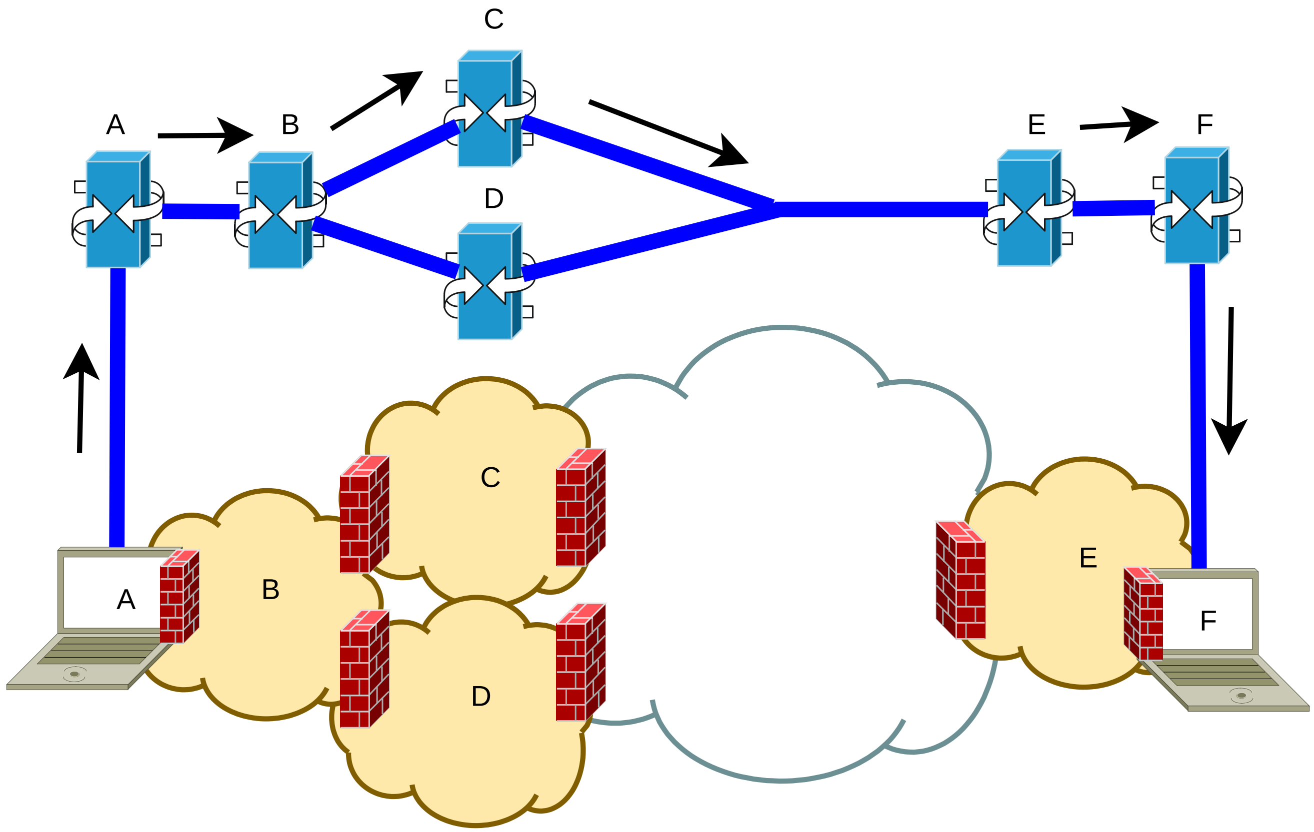

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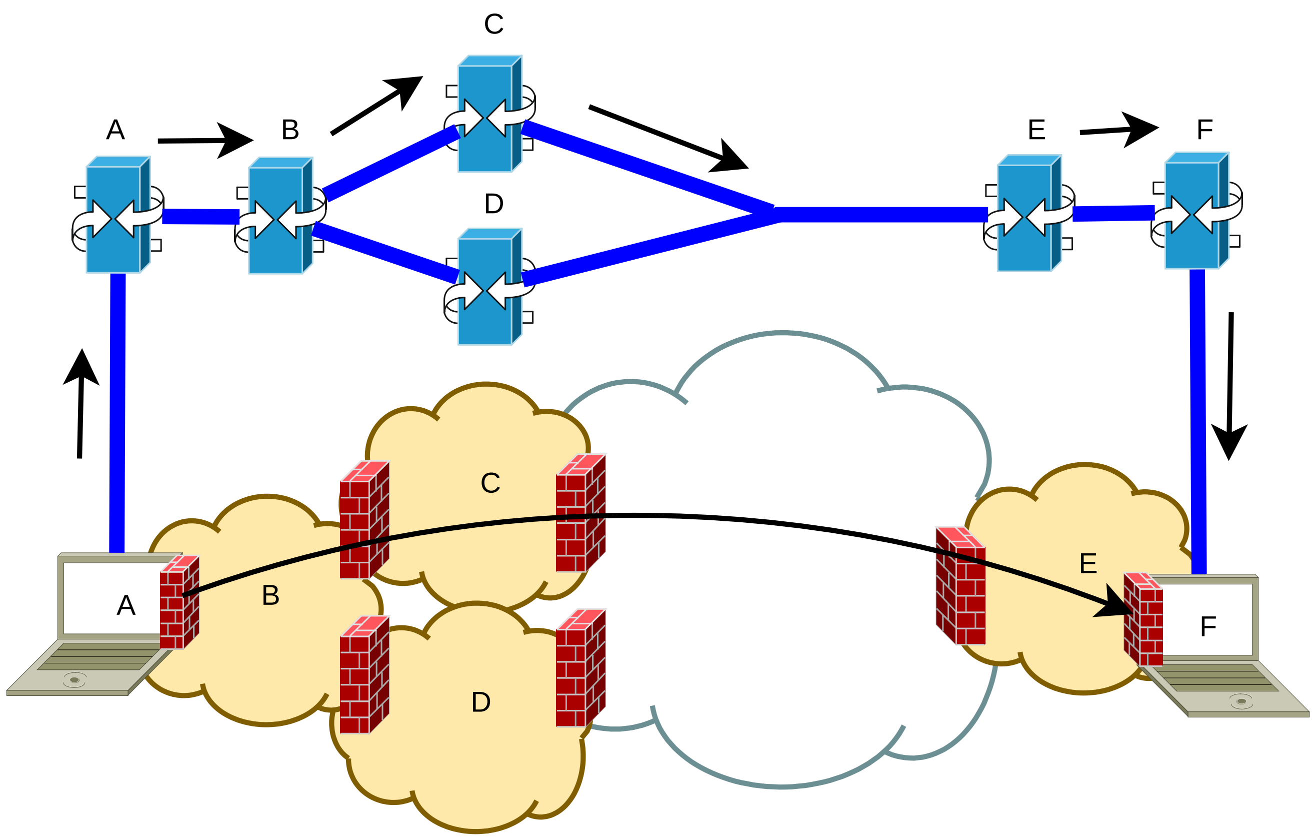

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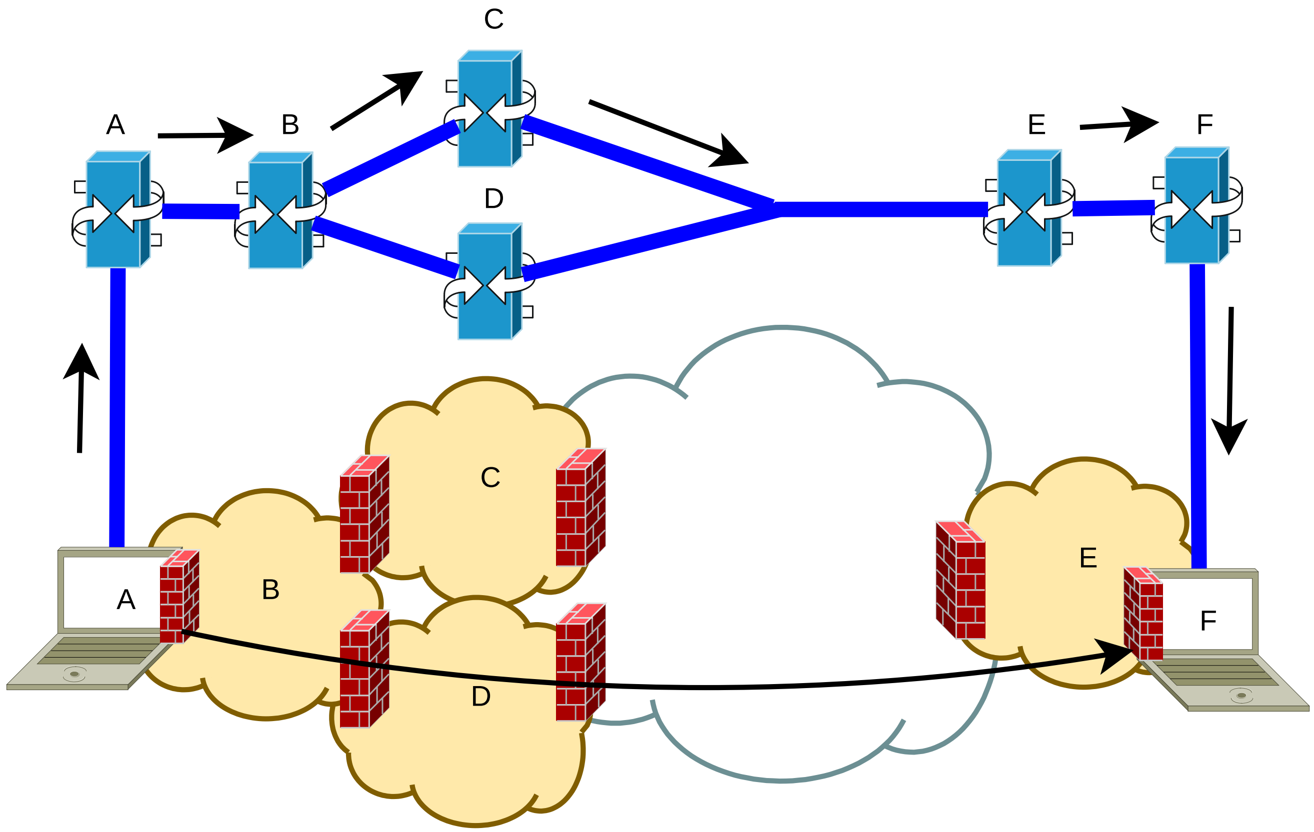

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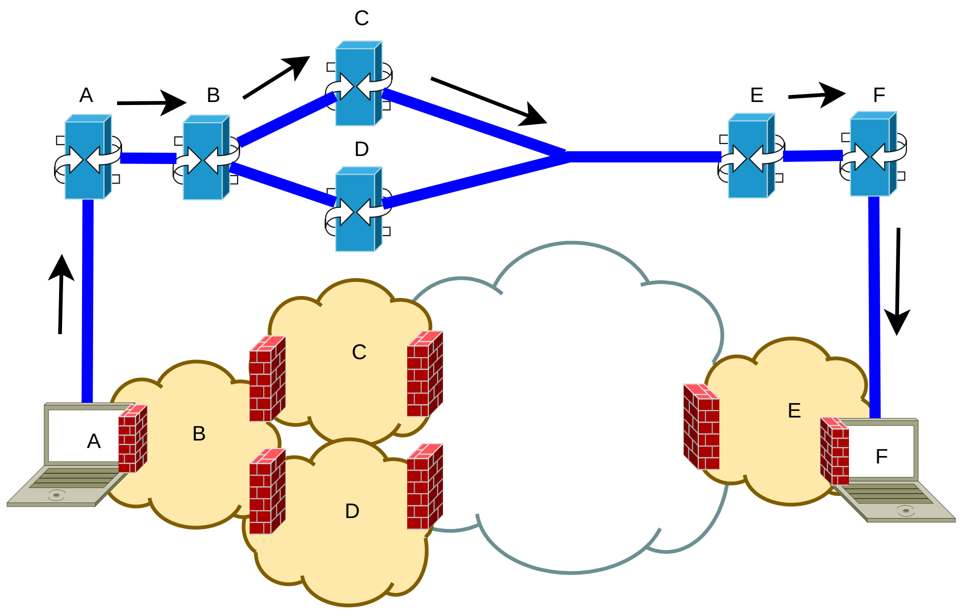
Turning on data path



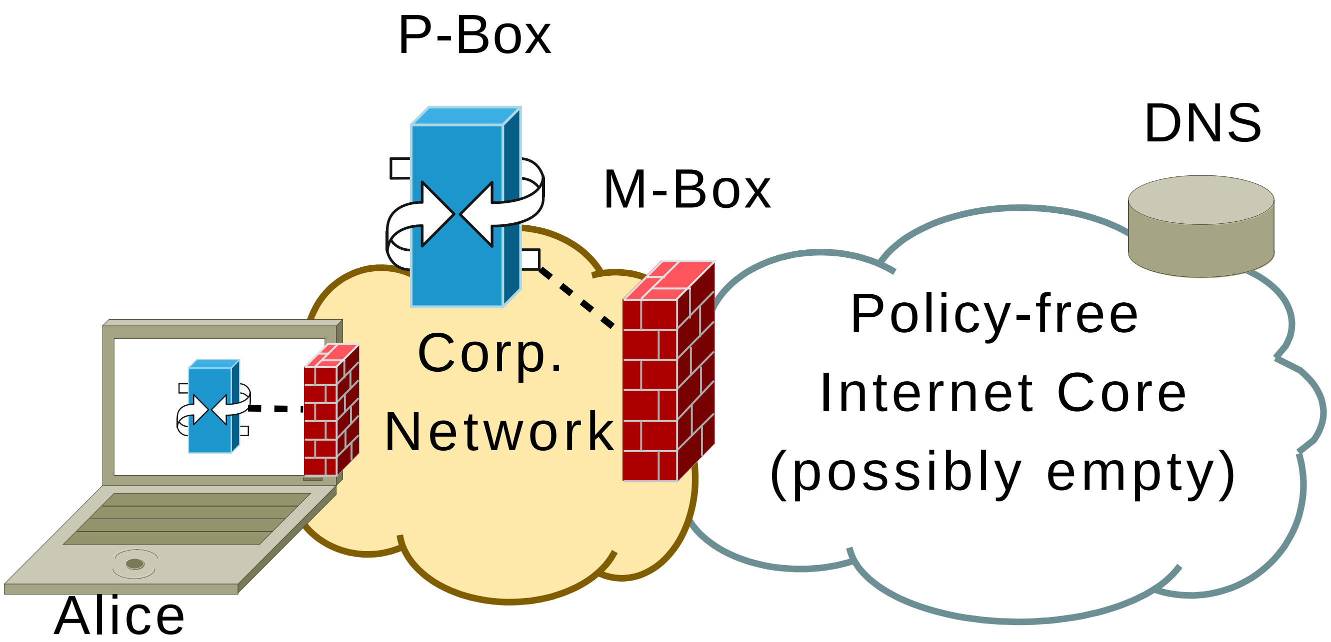
How to determine impending data path?

- Control plane fixes path
  - Constraining (virtual circuit)
- Control plane guesses path
  - Recovers from incorrect guess

NUTSS

- User-friendly, long-term stable, aggregtable names
- Off-path signaling
  - Name-based overlay
  - Applies policy
  - Authorization token
- On-path signaling (of token)
  - Verify data-path works
  - Referral back to off-path if fail

NUTSS: Components



- P-Box/M-Box associated, possibly same device
- Also in-host
- P-Box overlay (parent-child, fan-in, fan-out)

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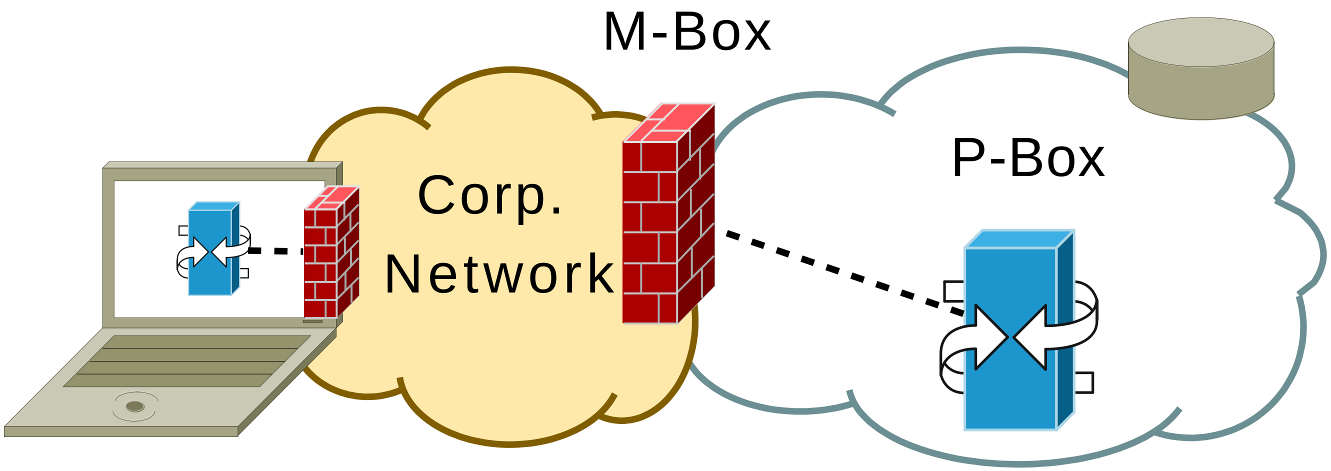

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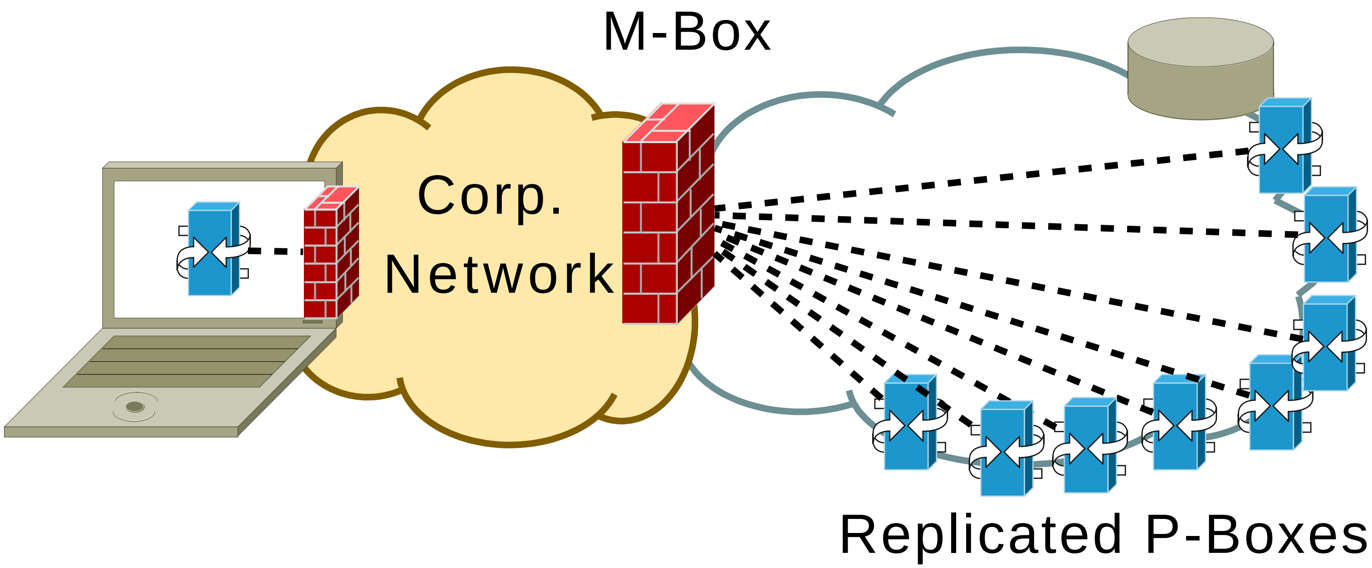

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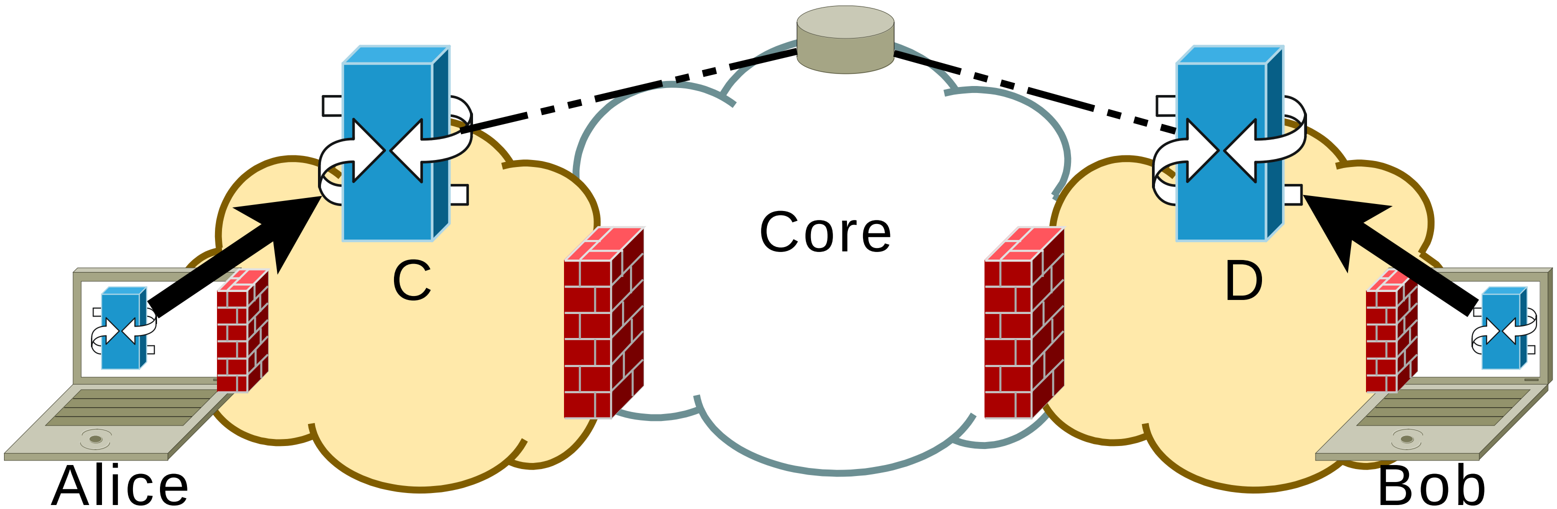
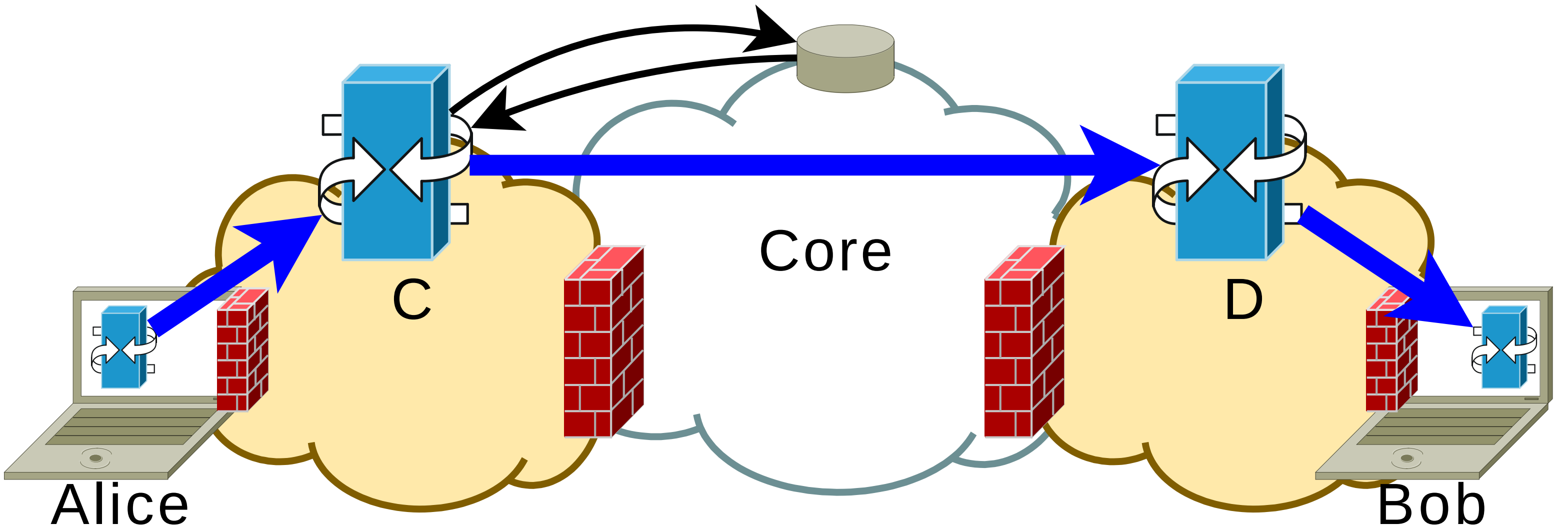
NUTSS: Name-Routing



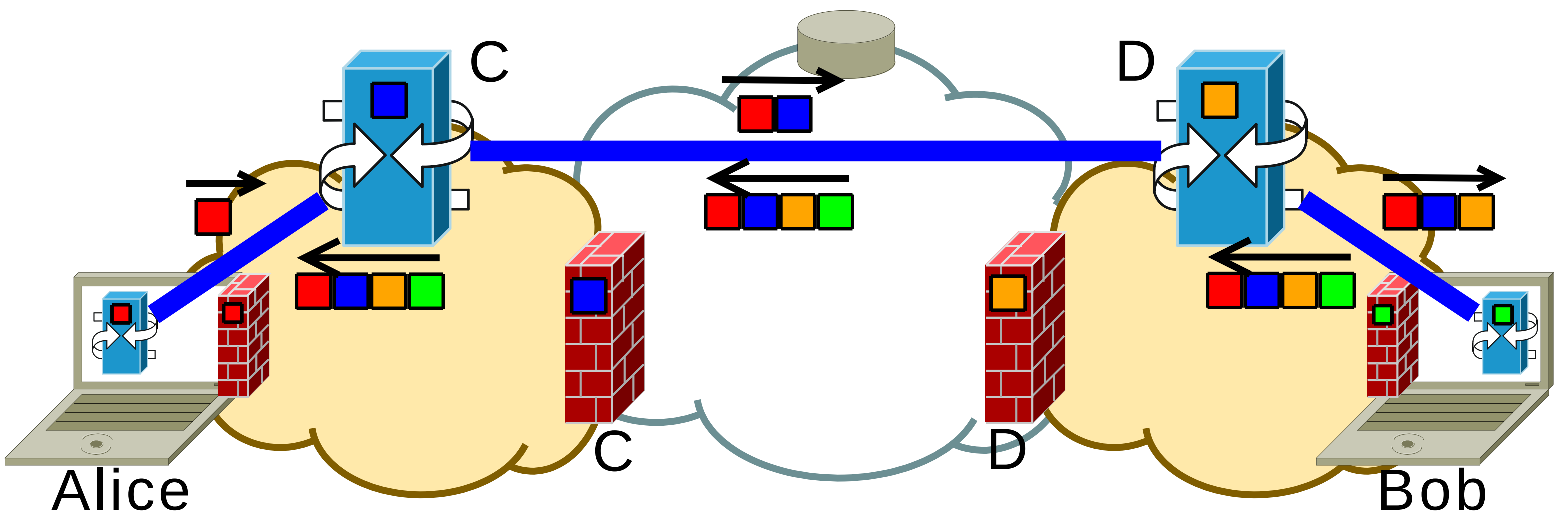
Endpoints register with P-Box chain in front.
DNS has outermost P-Box address.

NUTSS: Name-Routing



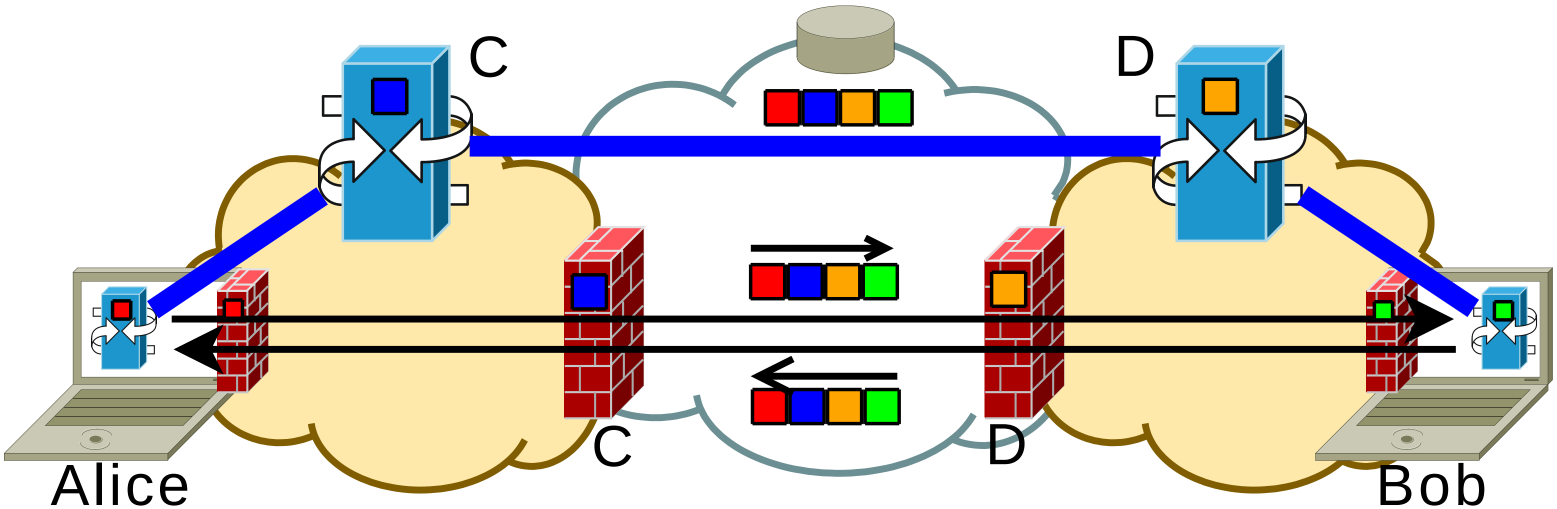
Up (config./discovery), Across (DNS),
Down (registration)

NUTSS: Name-Routing (Tokens)



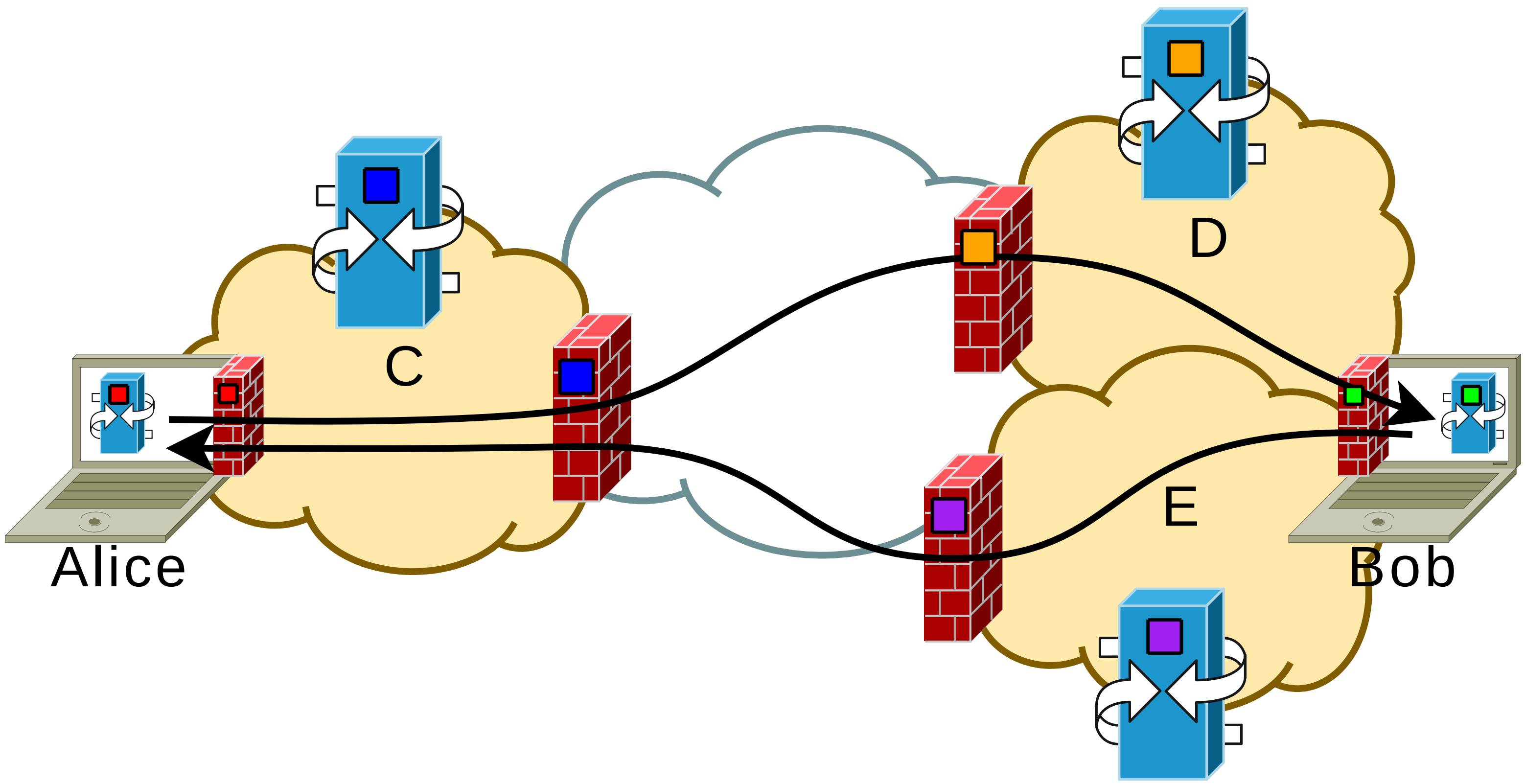
- P-Box gives token ⟨nonce, next-hop⟩ to M-Box via endpoint.
- Set of tokens. One for each P-Box/M-Box pair.
- Exchange effective addresses (may be of M-Box)

NUTSS: Address-Routing



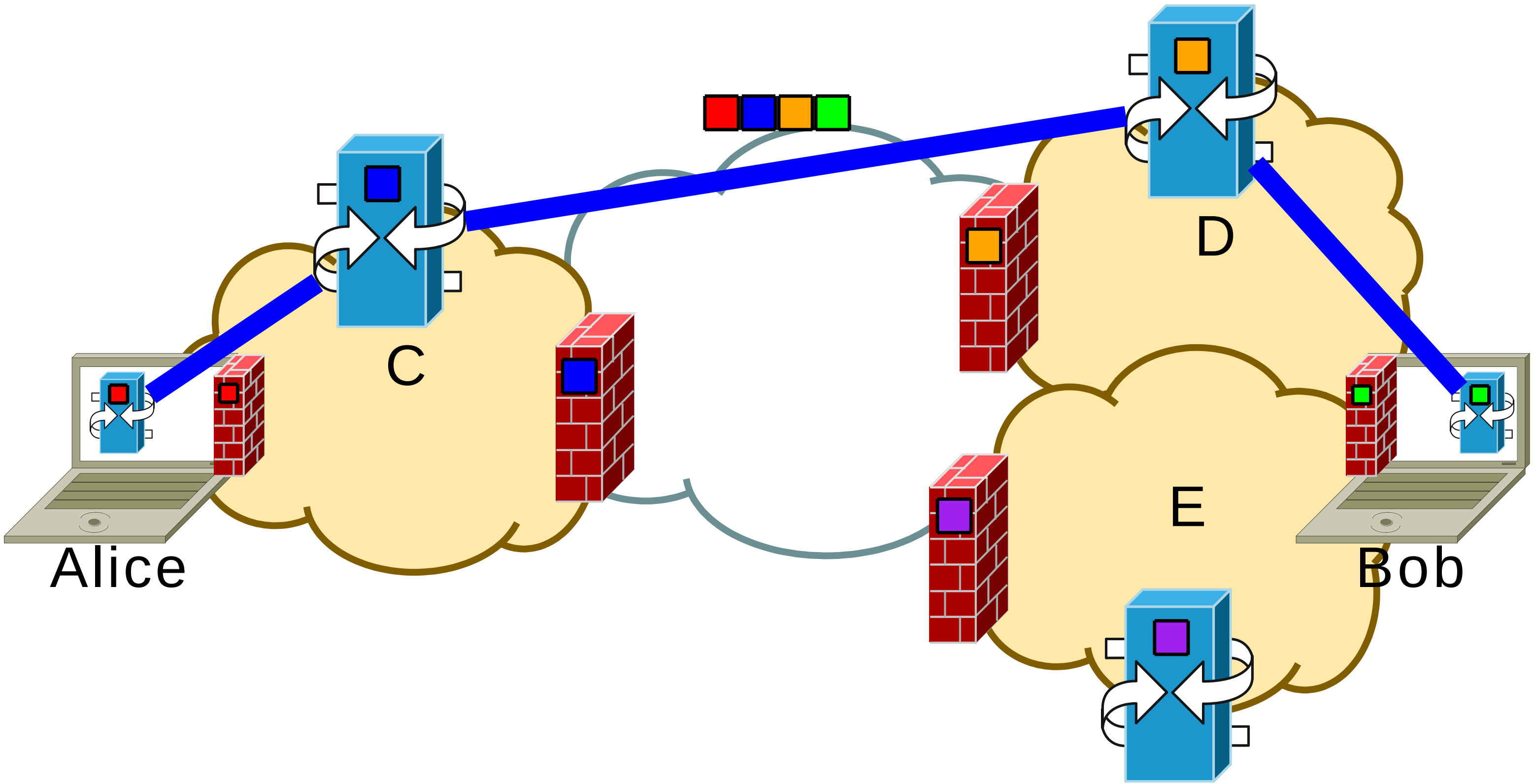
Once endpoint has effective address and tokens

NUTSS: Referral



What if address and name routed paths differ

NUTSS: Referral



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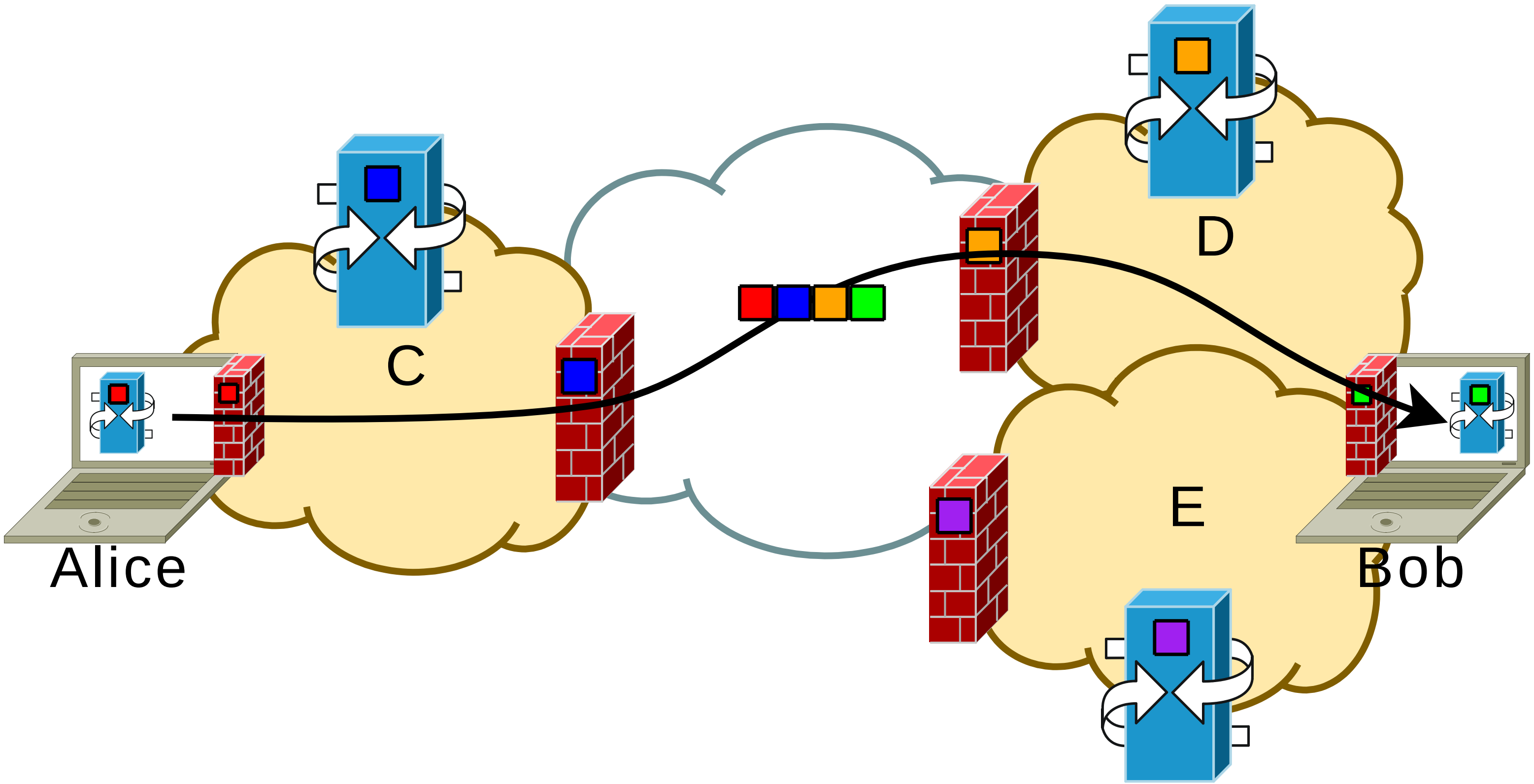

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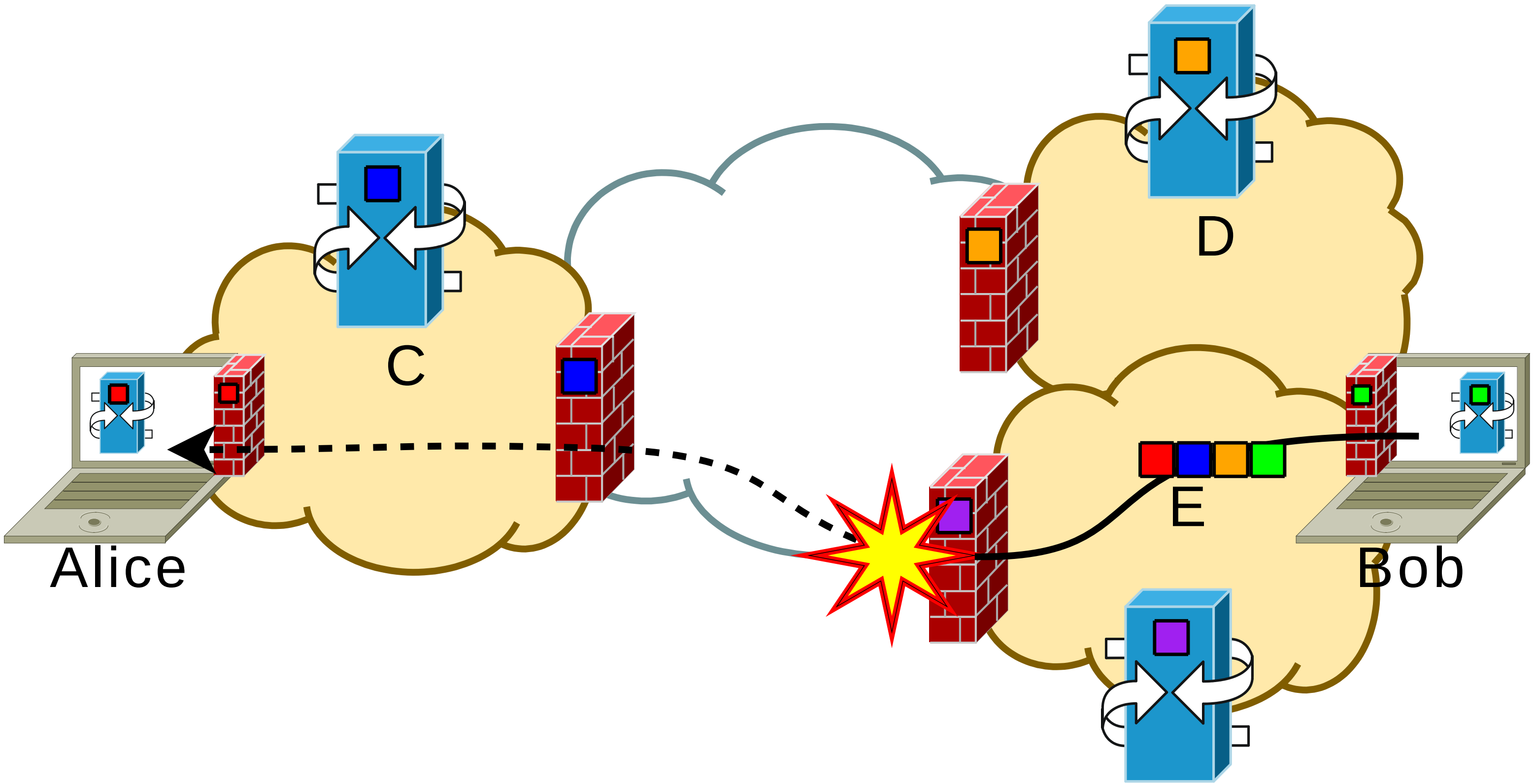

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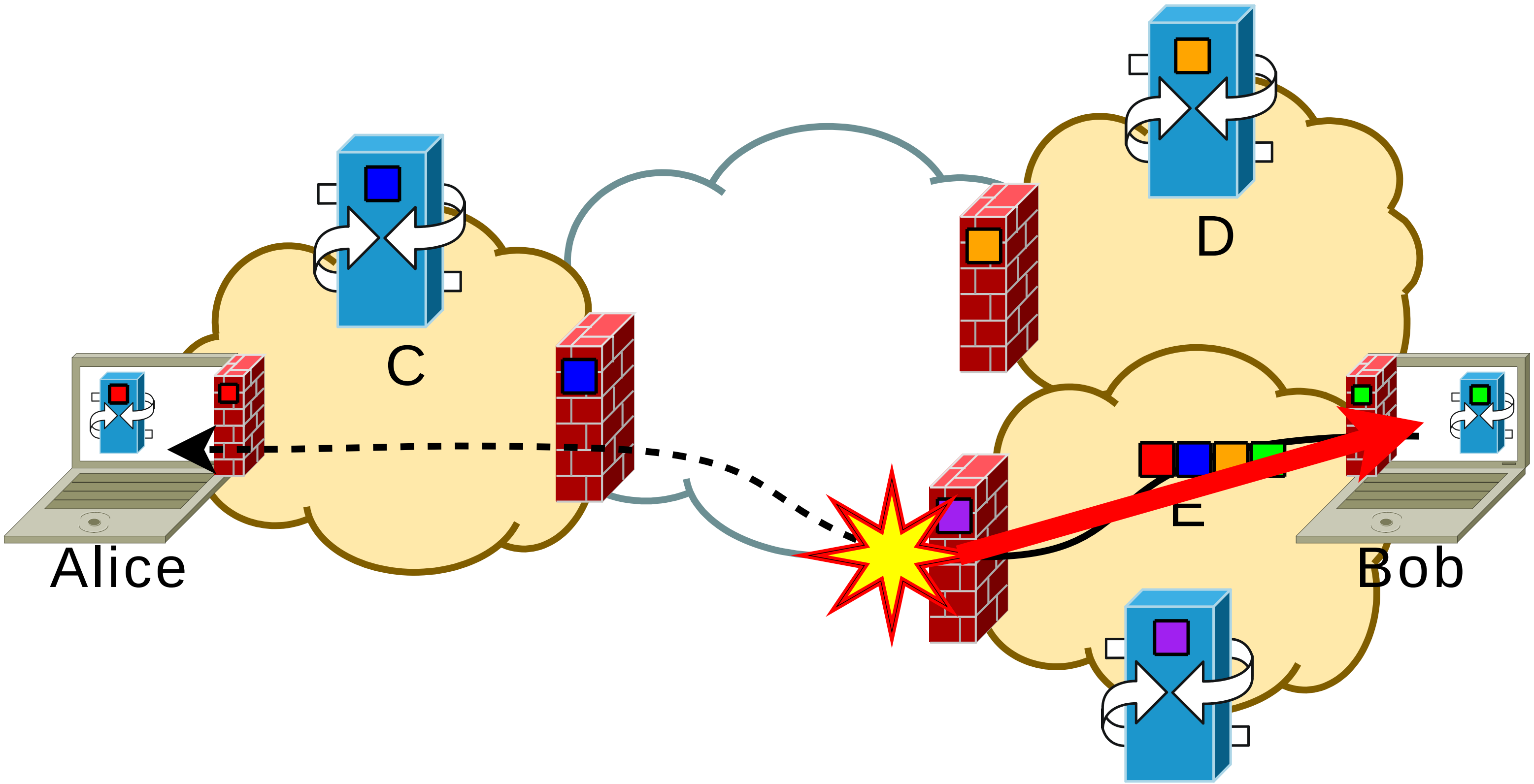
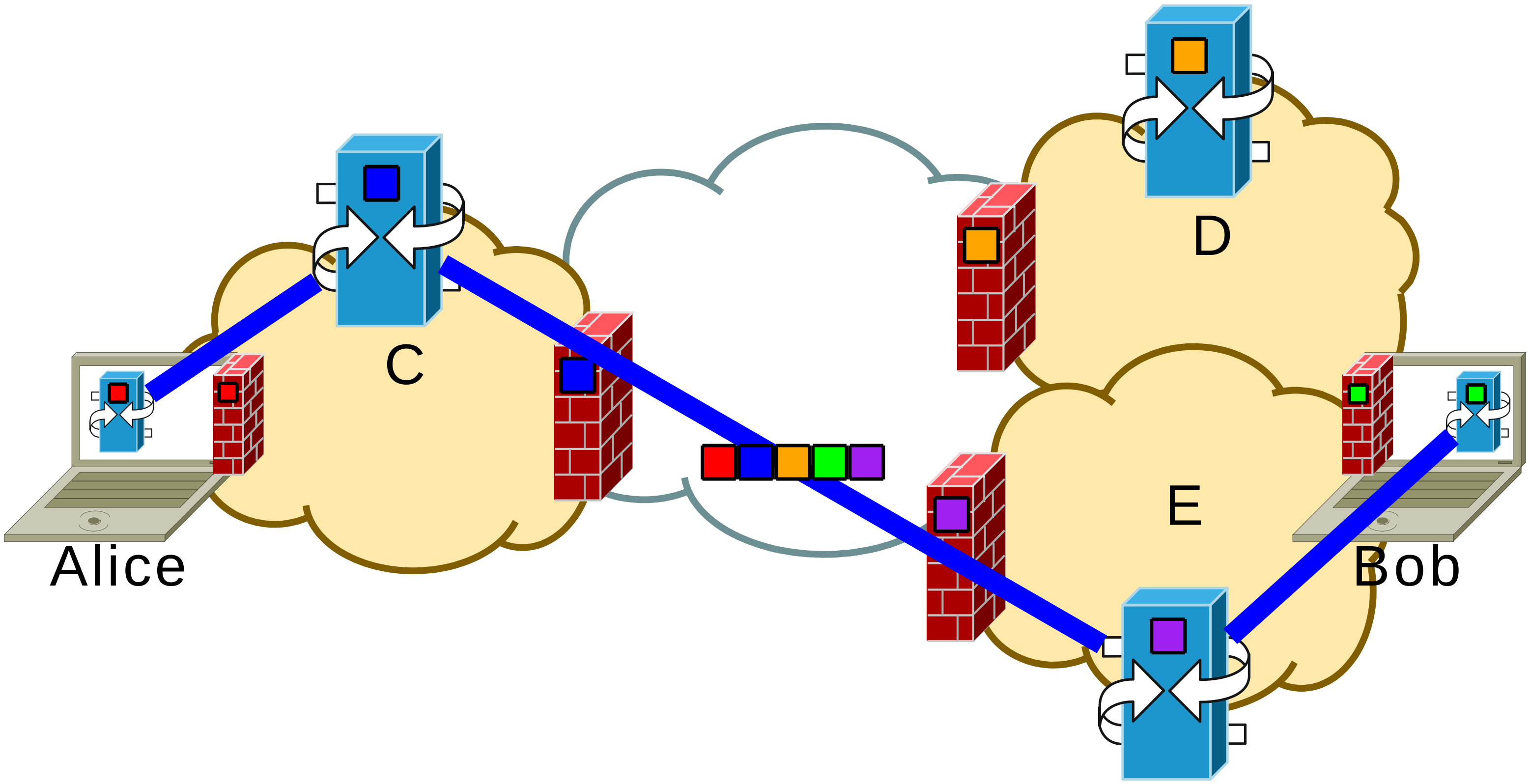


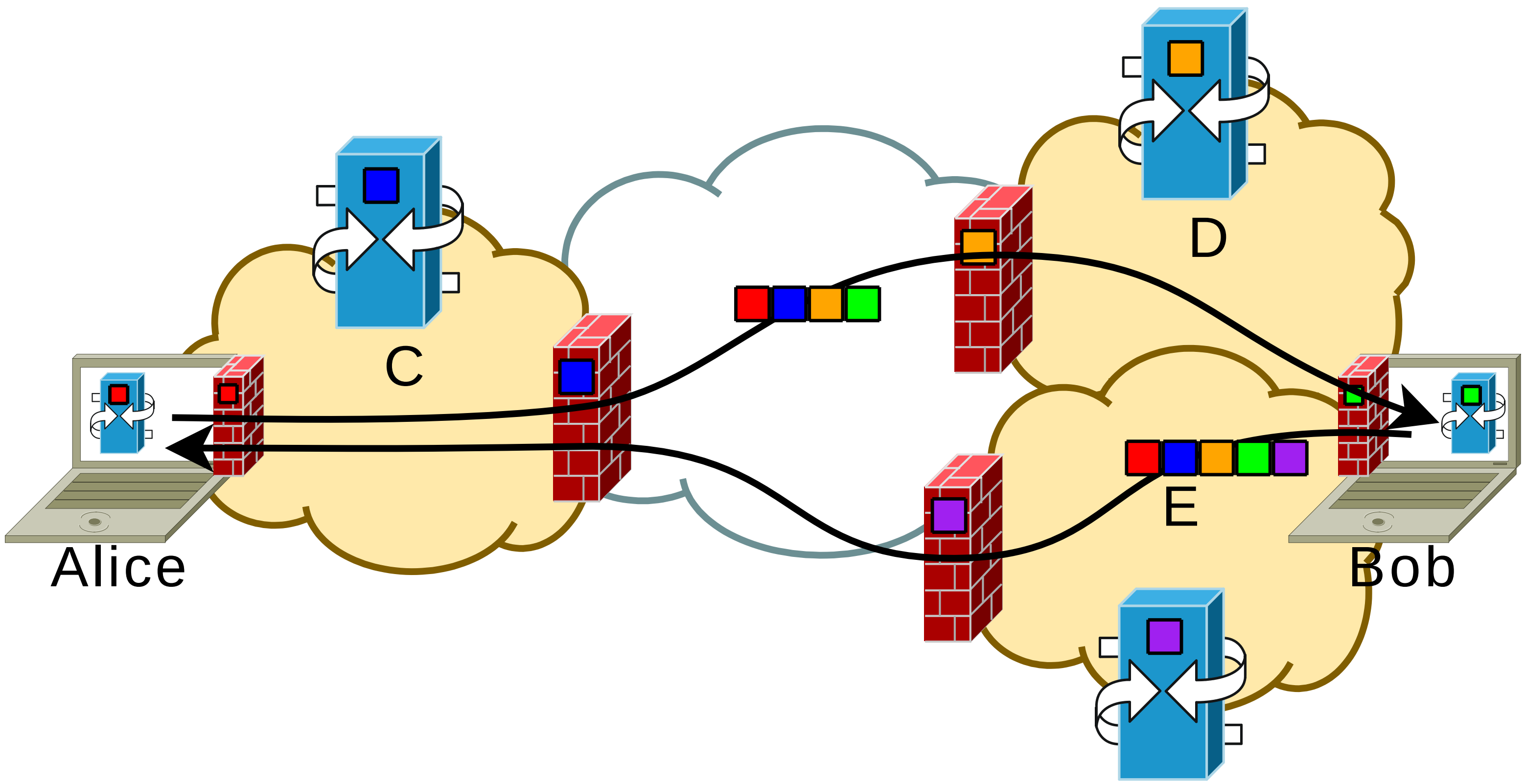
Referral from M-Box to P-Box

NUTSS: Referral



Resumes name-routed signaling for more tokens

NUTSS: Referral



Resumes name-routed signaling for more tokens

NUTSS: Some Use Cases

- Mobility
  - Register new address with P-Box overlay. Renegotiate flows.
- NAT Traversal
  - Exchange hole-punched address and port over name-routing
- Anycast, Multicast
  - Multiple endpoints share same name
  - P-Box forwards to one (to all for multicast).
  - Address routed path negotiated (possibly application multicast or IP multicast)
- Protocol negotiation
  - Endpoints advertise software stack (transport, security, network etc.)
  - P-Box filter out unsupported stacks

NUTSS: Incremental Deployment

1. Update applications to perform dual-signaling. 3-rd party P-Box service.
   - Implemented as a userspace library. Works with legacy apps.
   - P-Box service on `nutss.net`
   - NAT traversal helper M-Box on Planetlab
2. Networks deploy P-Boxes. Only weak access control (but better than firewalls today).
3. Networks deploy M-Boxes. Strong access control.

Summary and Future Work

- End-Middle-End requirements, NUTSS architecture and protocol.
- Need for dual-signaling: Name-routed and address-routed signaling
- Coupling between the two can solve a broad range of Internet problems
  - Network ACL, mobility, multihoming, steering, protocol negotiation, ...
- Pursued in the E-M-E RG in the IRTF
- Investigate non-FQDN based naming, non-DNS "across" routing, multipath connections, secure P-Box discovery

`http://nutss.net/`

Related Work

- Endpoint-only control
  - TRIAD, i3, IPNL, HIP, SHIM6
- Middle involved only in name resolution
  - Metanet, Plutarch, UIA, DONA, AVES

- Off-path only
  - SIP
- On-path only
  - i3, HIP, RSVP

NUTSS: Optimizations

- Lower latency
  - Piggyback application-data in signaling messages
- Faster authorization
  - Use self-certifying ID's

NUTSS: Dual-Signaling

Name-routed

- $\langle$user@domain, app$\rangle$
- P-Boxes (overlay)
- Path always exists (Default on)
- Policy decision
- $\overrightarrow{\text{Tokens}}$

Address-routed

- IP address[2] and port
- M-Boxes (on IP path)
- Initially, does not exist or blocked (Default off)
- Policy enforcement
- $\overleftarrow{\text{Referral}}$

[2] or other address e.g. i3, HIP, etc.