Using Overlay Networks for ID/locator Split Architecture Research

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Outline

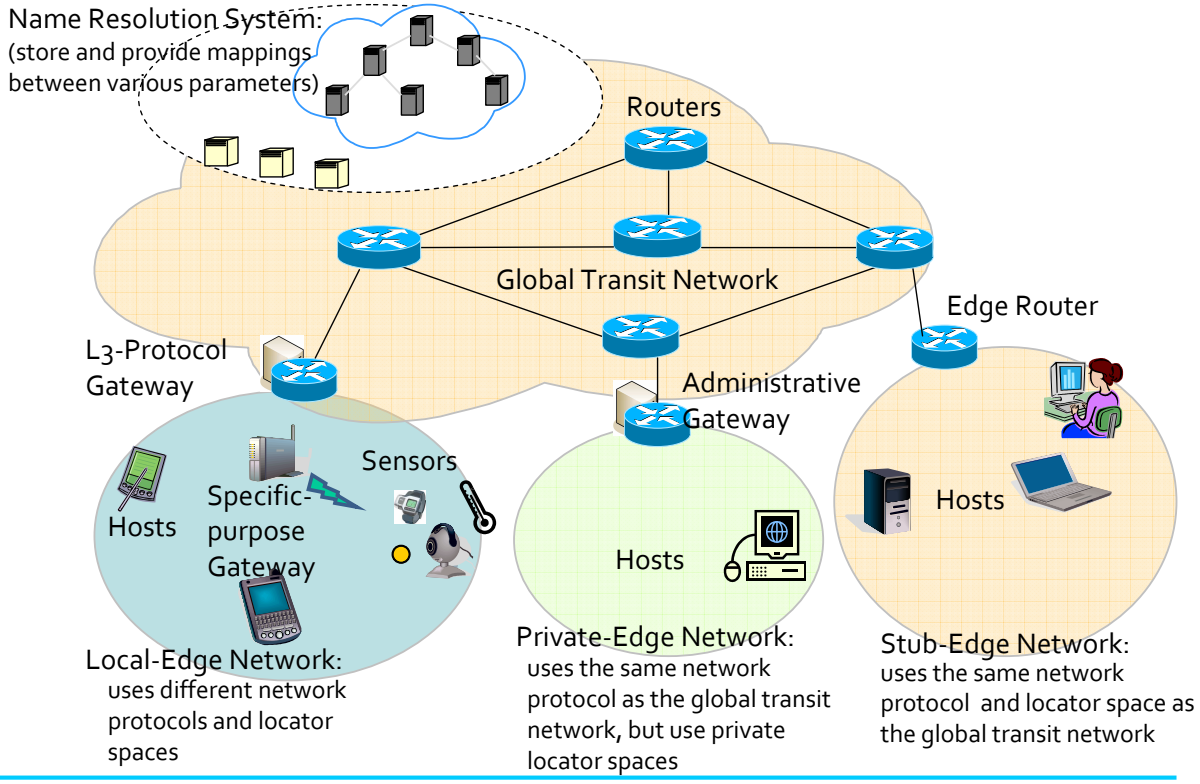
- Current Internet architecture limitations
- ID/locator split concept
- HIMALIS architecture overview

- Implementation over PlanetLab
- Performance studies

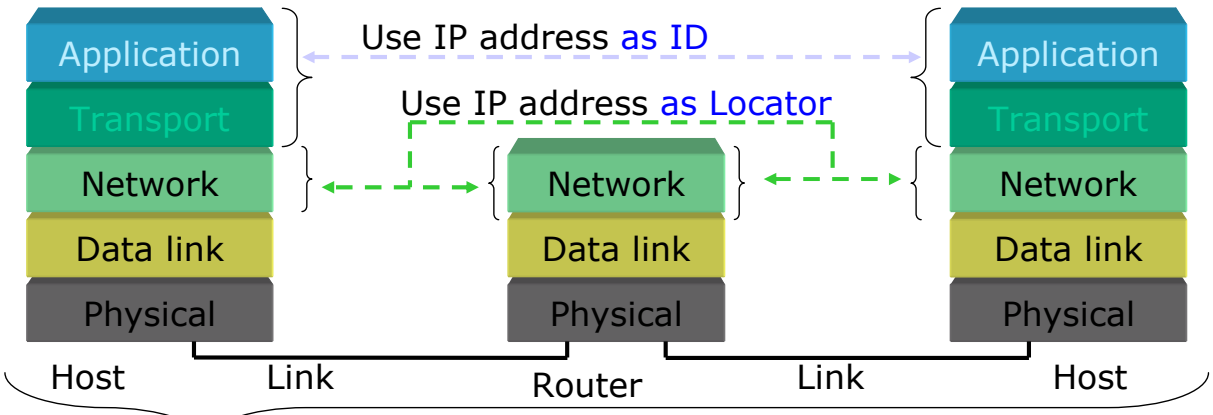
- Summary and future work

Envisioned heterogeneous networks of the future

Heterogeneous in terms of network layer protocols used in edges



Current Internet architecture limitations



IP address as both ID and locator

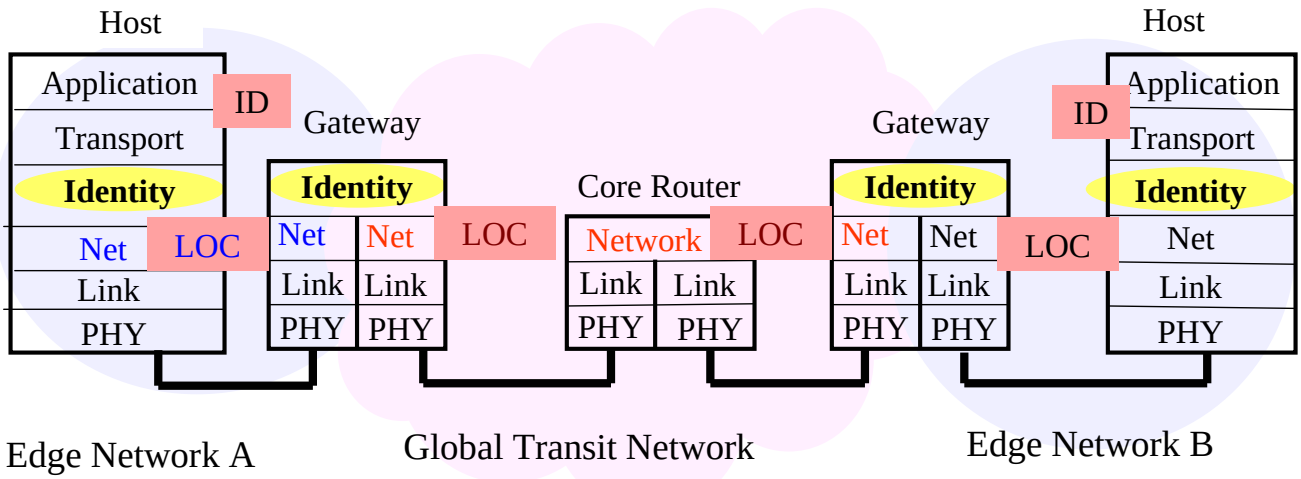
Limitations on

- supporting heterogeneous network layer protocols and locator spaces
- mobility and multihoming
- scalable routing, traffic engineering

Future Internet architecture should be based on ID/locator split

ID/Locator (LOC) split network architecture concept

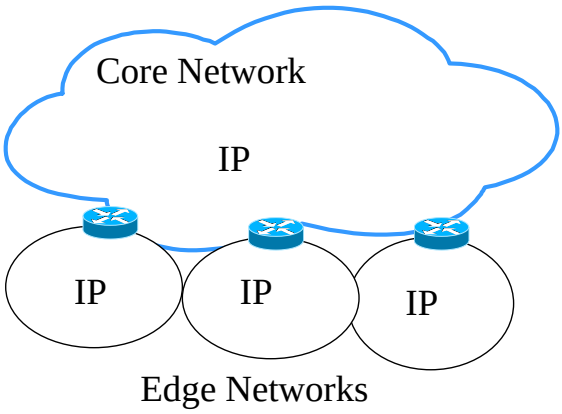
- IDs and locators are derived from distinct namespaces
- IDs are used in app/trans layers to identify hosts/sockets/sessions
- LOCs are used in net layer to locate hosts by routing systems

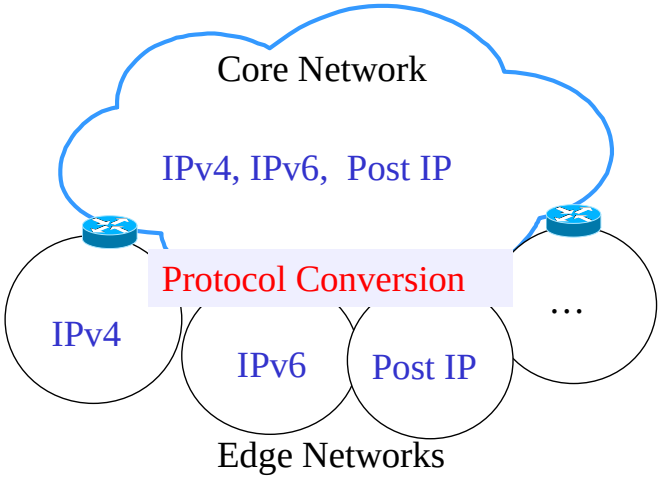


ID/LOC split for heterogeneity support

従来インタネット:
require homogeneous network protocol

新世代ネットワーク:IDロケータ分離
can support various network protocols





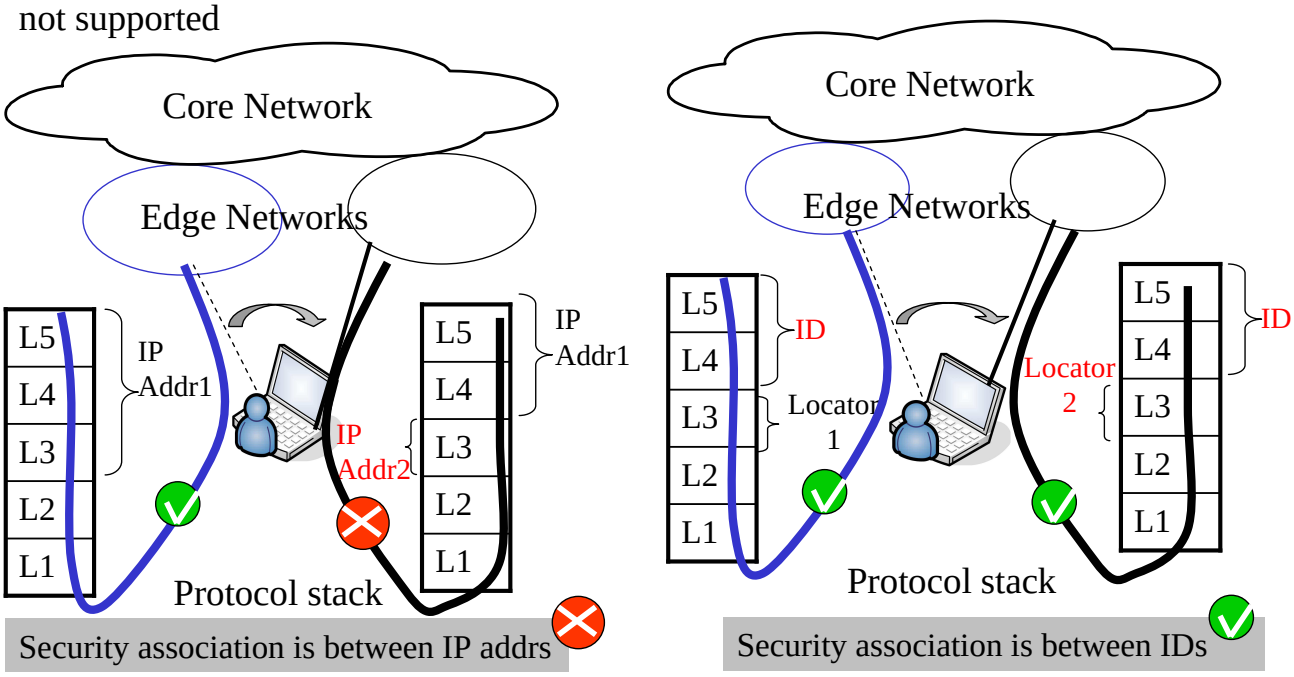
-Difficult to connect tiny devices, e.g., sensors

-Connect tiny devices
-Extendible to meet future demands

ID/LOC split for mobility, multihoming support

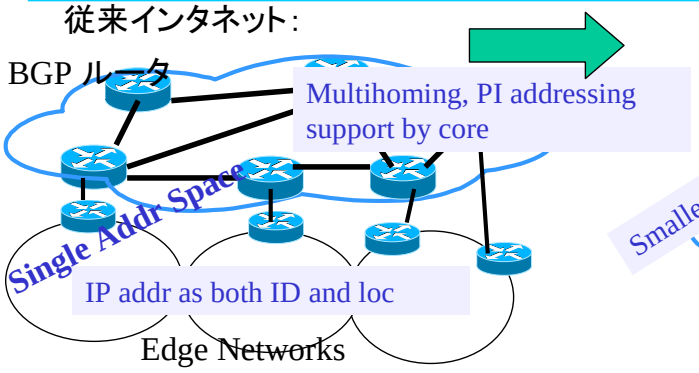
従来インタネット:
mobility/multihoming
not supported

新世代ネットワーク:IDロケータ分離:
mobility/multihoming well supported

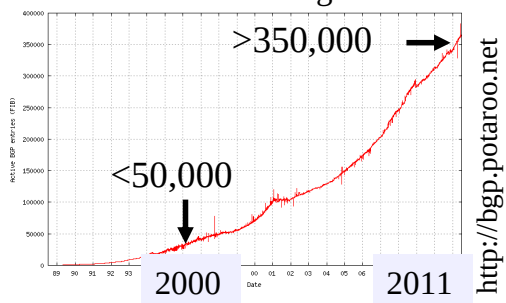


ID/LOC split for scalable routing

従来インタネット:
BGP ルータ

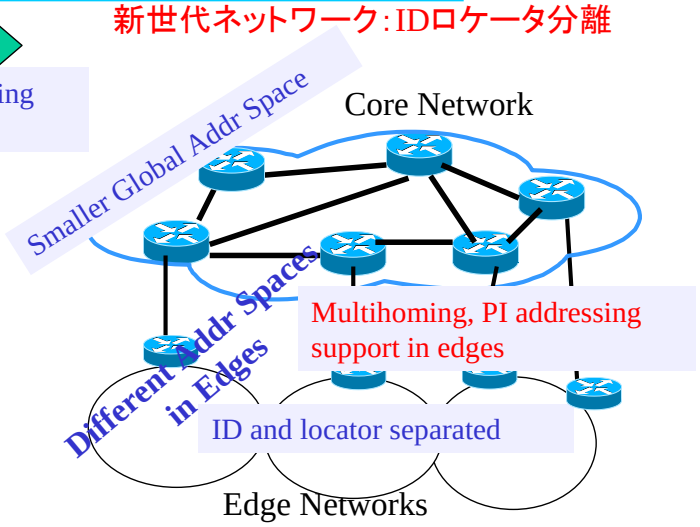


BGP table entries increasing fast



-Higher routing overhead
-Lower forwarding speed

新世代ネットワーク:IDロケータ分離

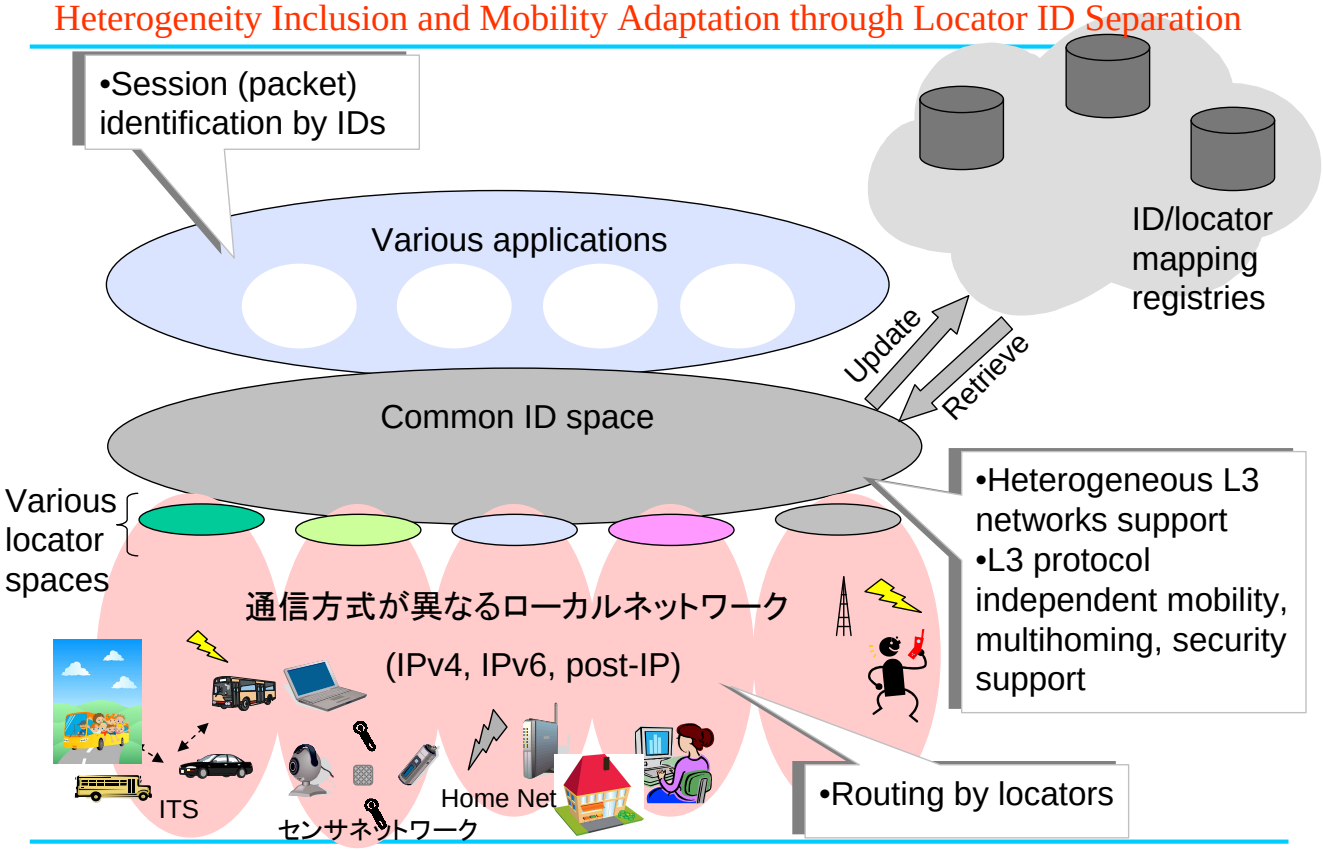


Reduce BGP table size and updates

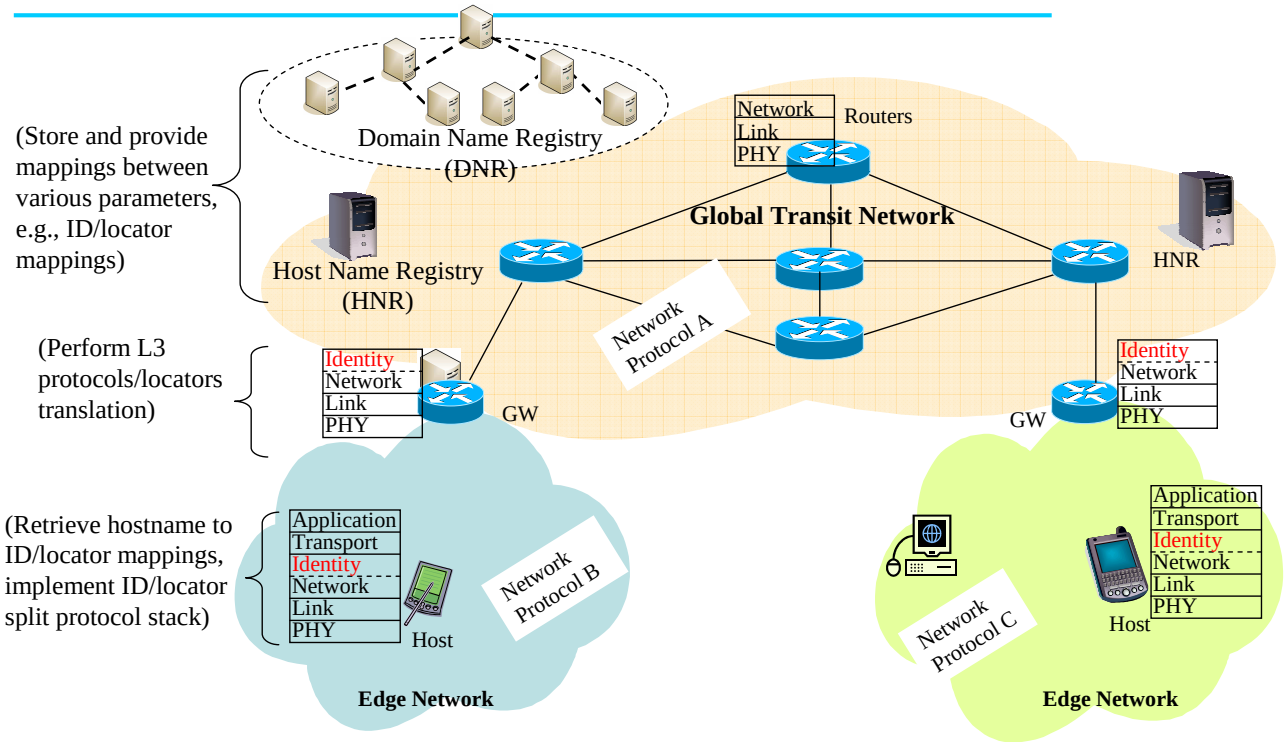
- No overhead of multi-homing, PI addressing in BGP
- No overhead of edge network readdressing in BGP

Our proposal: HIMALIS architecture

Heterogeneity Inclusion and Mobility Adaptation through Locator ID Separation



HIMALIS architectural components



Edge networks with heterogeneous L3 protocols/locator spaces

HIMALIS architectural components (cont'd)

- DNR:
  - store mappings between domain names and ID/locator of HNR; are in hierarchical structure like DNS
- HNR:
  - store mappings between *hostnames and ID/locator of hosts; are not in hierarchical structure
- GW:
  - perform L3 protocol/locator translation in packet headers using ID tables when edge and global transit networks use different protocols
- Host:
  - retrieve ID/locator mappings from the name resolution system consisting of DNR and HNR
  - perform ID/locator mapping, mobility and multihoming functions from the identity layer

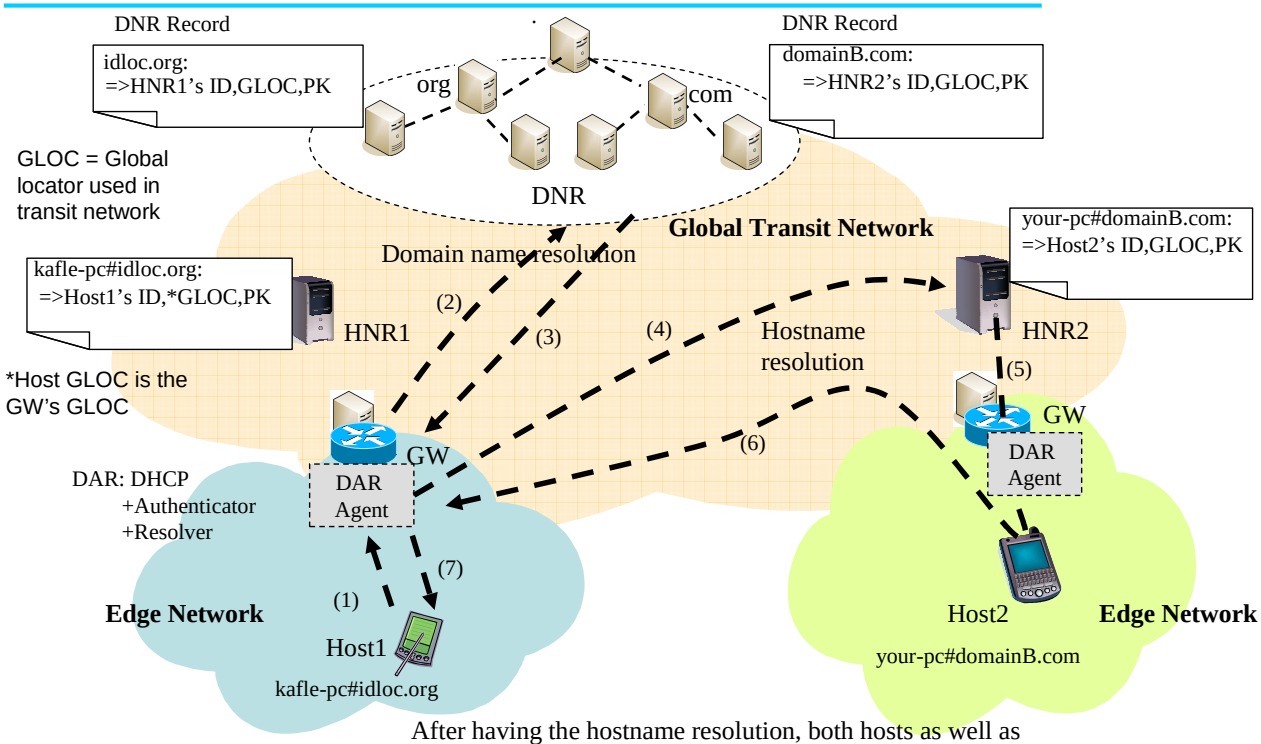
*Hostname:

- a global hostname consists of local hostname and domain name parts
- e.g. mypc#domainA.com
  (mypc: local hostname; domainA.com: domain name)

Communication procedures (overview)

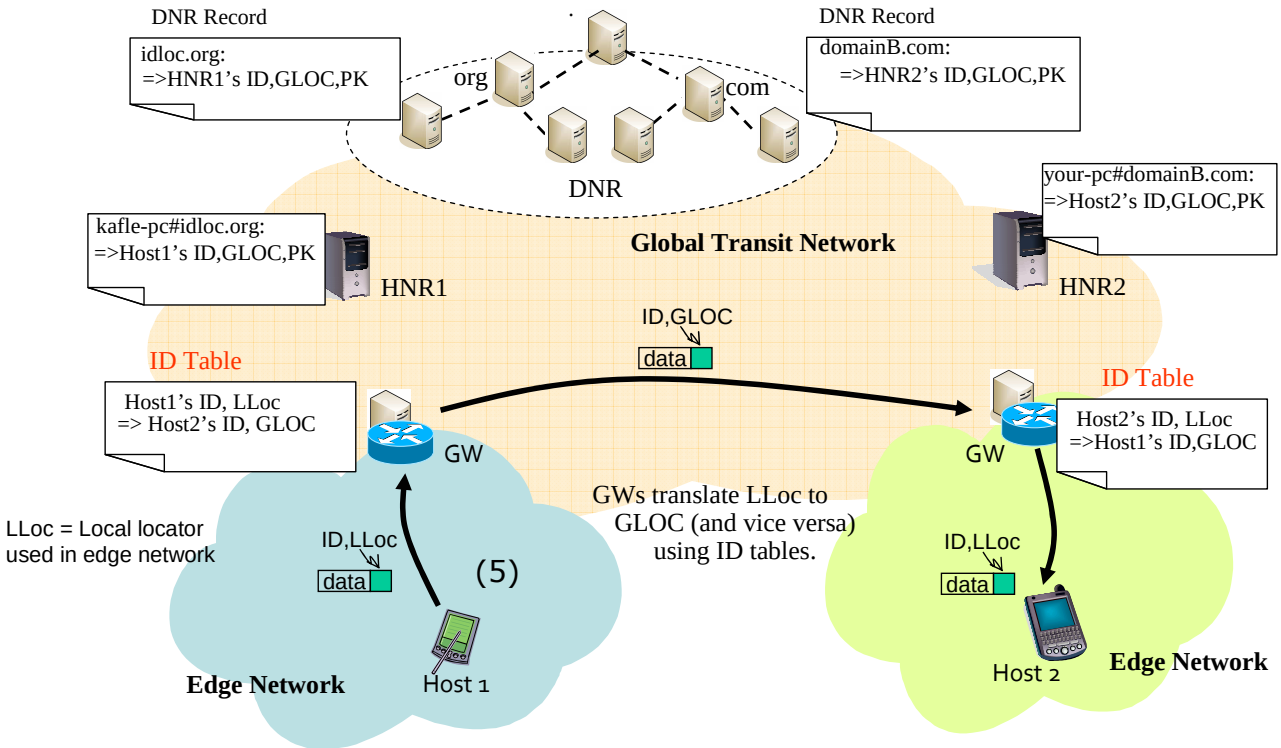
- Hostname to ID/locator resolution (process shown in next slide):
  - Source host resolves destination's hostname into ID and locator by sending a query to the resolver located in the source edge network (possibly collocated with GW). Resolver first resolves the domain name into HNR's ID and locator from a DNR, and then sends another query to the HNR to obtain the destination host's ID and locator.
  - ID/locator mapping cache in GWs: The resolvers provide the source and destination hosts' ID/locator mappings to the both GWs of source and destination networks.
- Using ID/locator in host protocol stack: IDs are used in application and transport layers; IDs mapped to locators in the identity layer; IDs appear in identity header and locators in L3 header of packets. Multihoming: one ID mapped to multiple locators.
- Protocol translation: GW translates L3 protocols using ID/locator mapping cache stored in the ID table when the edge and transit networks use different L3 protocols.
- Mobility: mobile host initiates signaling; GW assists in mobility signaling; the old GW forwards packets to the new GW.
- Security: hosts use HNR records to verify each other's identity and establish security context.
- Routing: core routing system is kept stable by hiding edge configuration changes from the global transit network.

Hostname resolution process

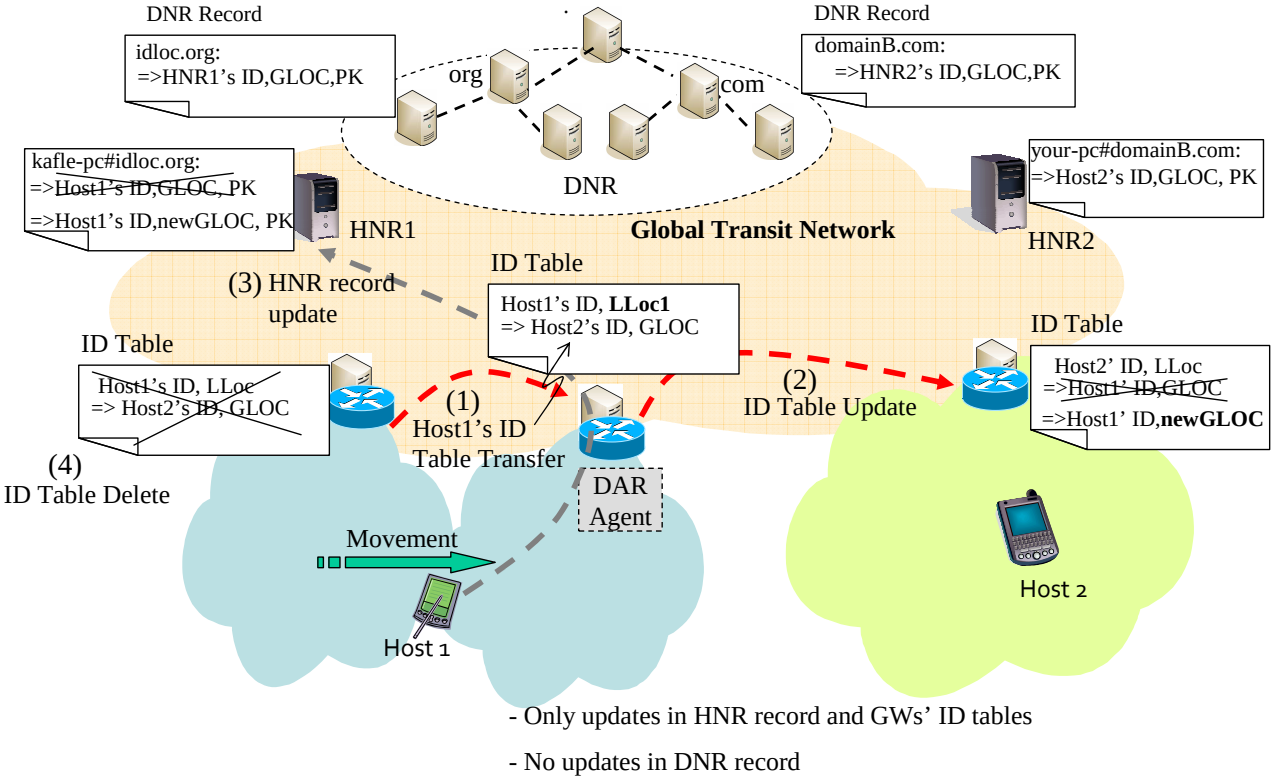


After having the hostname resolution, both hosts as well as GWs have host ID/locator mappings in their ID tables (shown in the next slide).

ID tables and data communication



Mobility signaling



- Only updates in HNR record and GWs' ID tables
- No updates in DNR record

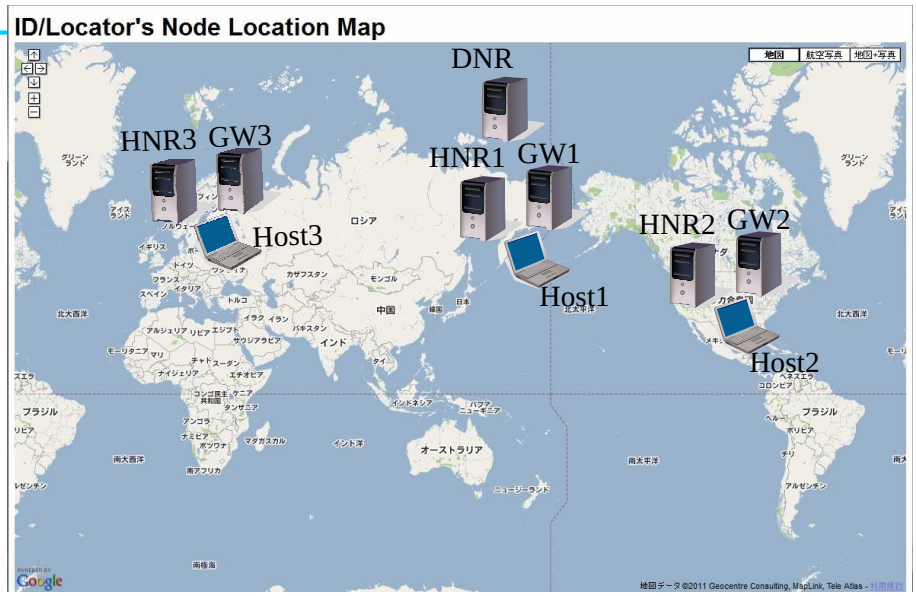
Experiments over PlanetLab

PlanetLab is helpful for the HIMALIS's performance study mainly because of its two aspects: (a) it can be used to distributedly store and retrieve ID-to-locator mapping records, and (b) it can be used to concurrently support multiple overlay routing mechanisms, some based on IDs and the others based on different types of locator spaces.

Implemented in two patterns

1. All components over PlanetLab nodes
2. Only name resolution system (DNR+HNR) over PlanetLab; GWs and hosts located in a local network

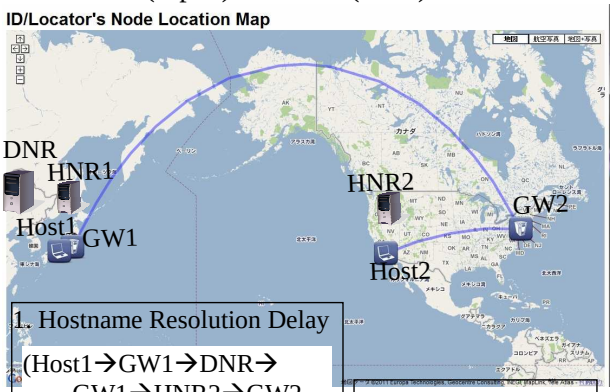
All components implemented over PlanetLab



- DNR, HNR1, GW1 and Host1 are implemented over different PlanetLab nodes located within Japan; HNR2, GW2 and Host2 are in USA; and HNR3, GW3 and Host3 are in Europe.
- Host1 communicates with Host2 and Host3 in different instants. We measured the followings 5 times:
  - Hostname resolution delay
  - RTT

All components implemented over PlanetLab (cont'd)

- Host1(Japan) → Host2 (USA)



1. Hostname Resolution Delay

(Host1→GW1→DNR→ GW1→HNR2→GW2 →Host2→GW2→GW1 →Host1):

	Delay (sec)
1回目	4.399
2回目	2.574
3回目	2.742
4回目	2.394
5回目	2.687

2. RTT
(Host1 ←→ Host2)
= 0.2 ~ 0.5 sec (mostly)
= ~ 1.2 sec (sometimes)

- Host1 (Japan) → Host3 (Europe)

1. Hostname Resolution Delay

(Host1→GW1→DNR→ GW1→HNR3→GW3 →Host3→GW3→GW1 →Host1):

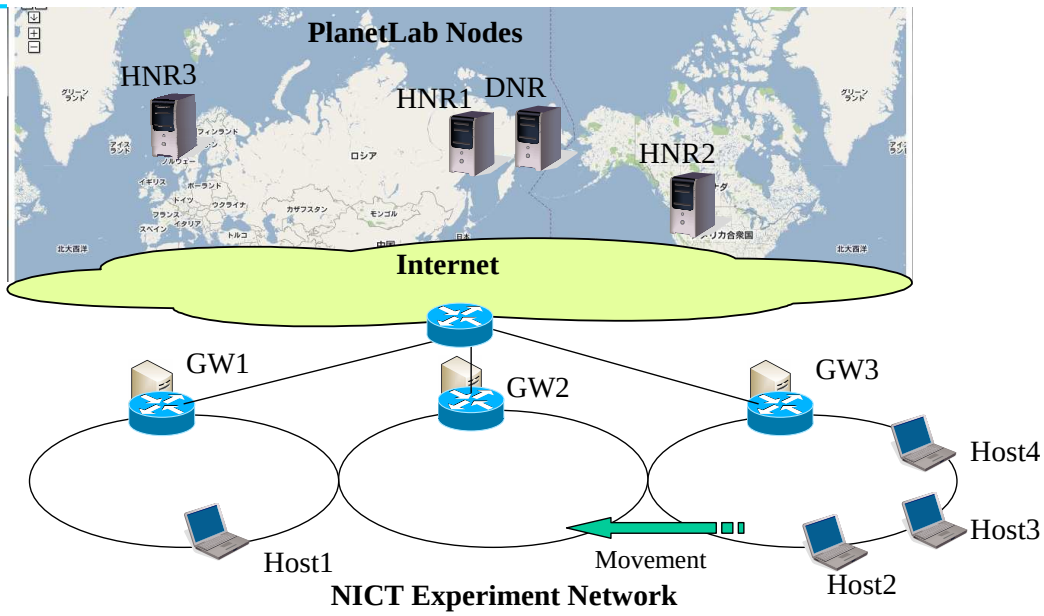
	Delay(sec)
1回目	3.880
2回目	3.006
3回目	3.162
4回目	3.101
5回目	3.885

2. RTT
(Host1←→ Host2)
= 0.3 ~ 0.6 sec (mostly)
= ~ 1.2 sec (sometimes)

Only name resolution (DNR+HNR) over PlanetLab

- To emulate an ID/locator mapping system distributed over the global Internet
- Keeping GWs and hosts in local networks
  - enables to do mobility experiments

Only name resolution (DNR+HNR) over PlanetLab (cont'd)



NICT Experiment Network

1. Host1 and Host4's ID/locator mappings are stored in HNR1 (in Japan); Host2's ID/locator mapping is in HNR2 (in USA), and Host3's is in HNR3 (in Europe)
2. Measured: hostname resolution delay when a host initiates a session, and HNR record update delay when the host changes its ID/locator mapping due to mobility

Only name resolution (DNR+HNR) over PlanetLab (cont'd)

Hostname Resolution Delays

Host2(USA)からHost1(JP)へ接続

(Host2→GW3→DNR→GW3 →
HNR1→GW1→Host1→
GW1→GW3→Host2):

	Delay (sec)
1回目	1.094
2回目	1.058
3回目	1.020
4回目	1.051
5回目	1.036

Average = 1.052
STD = 0.025

Host3(EU)からHost1(JP)へ接続

(Host3→GW3→DNR→GW3→
HNR1→GW1→Host1→
GW1→GW3→Host3):

	Delay (sec)
1回目	2.234
2回目	1.395
3回目	1.440
4回目	1.380
5回目	1.719

Average = 1.634
STD = 0.363

Host4(JP)からHost1(JP)へ接続

(Host4→GW3→DNR→GW3→
HNR1→GW1→Host1→
GW1→GW3→Host4):

	Delay (sec)
1回目	0.597
2回目	0.615
3回目	0.585
4回目	0.579
5回目	0.567

Average = 0.589
STD = 0.018

Observation:

a) Delay is less than 1sec when name resolution messages are confined to Japan.
b) It is slightly greater than 1 sec when they traverse USA and Japan.
c) It is about 2 sec when they traverse Europe and Japan.

Only name resolution (DNR+HNR) over PlanetLab (cont'd)

HNR Record Update Delay

Time duration from the instance the mobile host (located in Japan) sends an HNR record update request to the instance it receives the response from the HNR after having its record updated.

When Host2 moves (GW3→GW2)

Host2 updates HNR2(USA) record
by sending an update request

	Delay (sec)
1回目	1.732
2回目	1.093
3回目	1.480

Average = 1.435

When Host3 moves (GW3→GW2)

Host3 updates HNR3 (EU) record
by sending an update request

	Delay (sec)
1回目	1.397
2回目	1.226
3回目	1.238

Average = 1.287

When Host4 moves (GW3→GW2)

Host4 updates HNR1(JP) record
by sending an update request

	Delay (sec)
1回目	0.434
2回目	0.416
3回目	0.370

Average = 0.406

Observation:

a) HNR record update delays are almost similar when the HNR is located in USA or in EU; it is far less when the HNR is located within Japan.

Summary and future work

- Summary:
  - Future networks would be heterogeneous in terms of network layer protocols
  - ID/locator split-based HIMALIS architecture facilitates mobility across heterogeneous networks without straining core routing functions
  - Implemented HIMALIS components over PlanetLab and studied ID/locator mapping system's (control plane) performance
- Future work:
  - Implement on VNodes to study data plane performance (e.g. GW's scalability)