A Near Term Solution for Home IP networking (HIPnet)
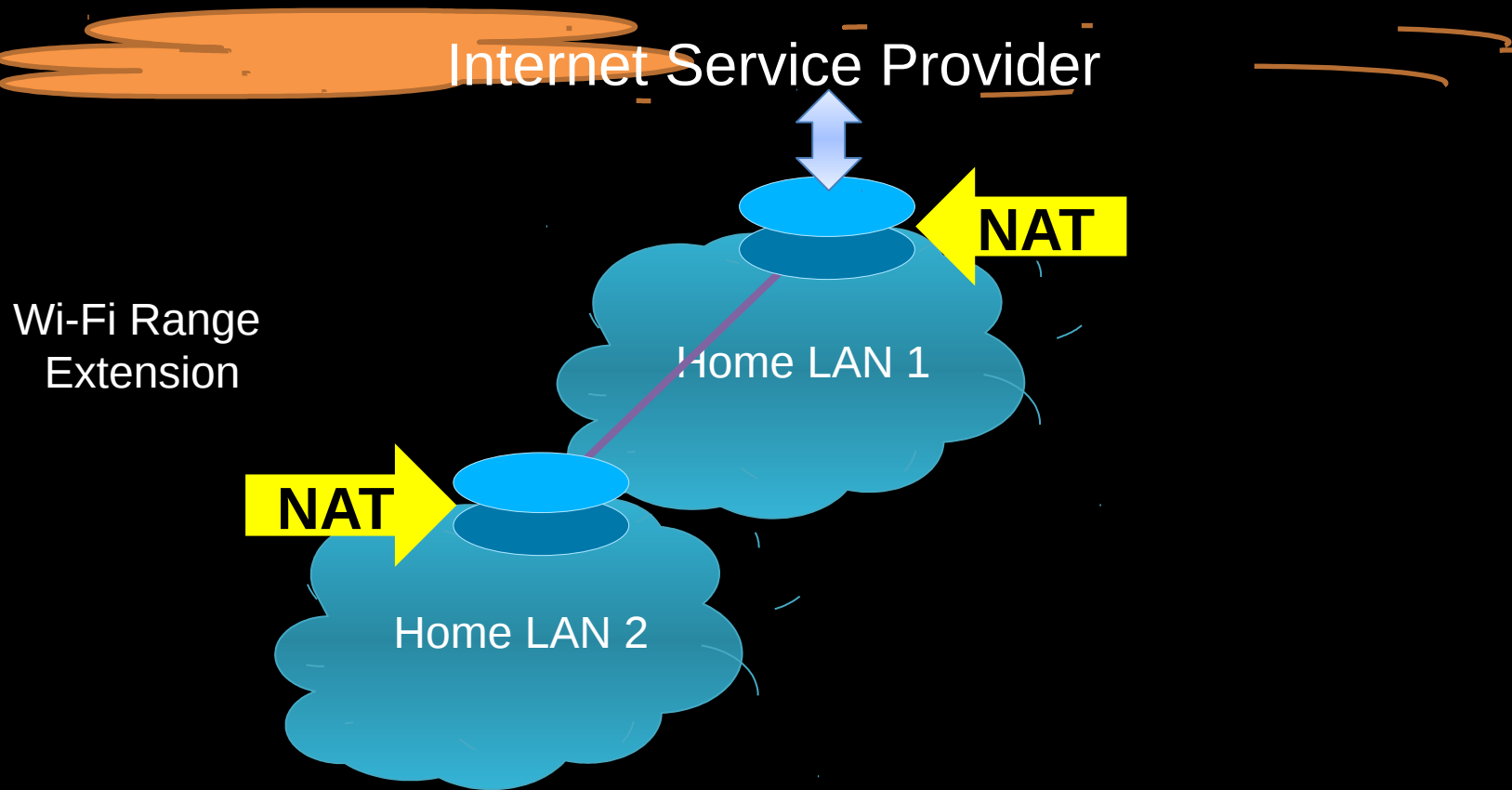
draft-grundemann-homenet-hipnet

RIPE 66 – Dublin – 14 May 2013

Chris Grundemann, Chris Donley,
John Brzozowski, Lee Howard, Victor Kuarsingh

Yesterday's Home Network

Emerging use cases for the home network

- Separation of guest users from home users
- Community Wi-Fi
  - Wi-Fi GW in the subscriber home is used to provide Wi-Fi roaming services
- Femto cell
  - GW in the subscriber home is used to provide cellular services
- Smart grid
- Security, Monitoring, & Automation
- Multi-homing
- Video content sharing and streaming between the devices inside the home
- IP video streaming from the internet
- Telecommuting and corporate IT requirements (e.g. network separation)
- Ever increasing devices in the subscriber home
- Emergence of Heterogeneous link layer technologies (e.g. low powered sensor networks) with different requirements

Tomorrow's Home Network

Internet Service Provider

Multiple SSIDs:
Private, Guest,
Community, ISP Branded,
Etc.

Wi-Fi Range
Extension

LAN

Home

Gateway

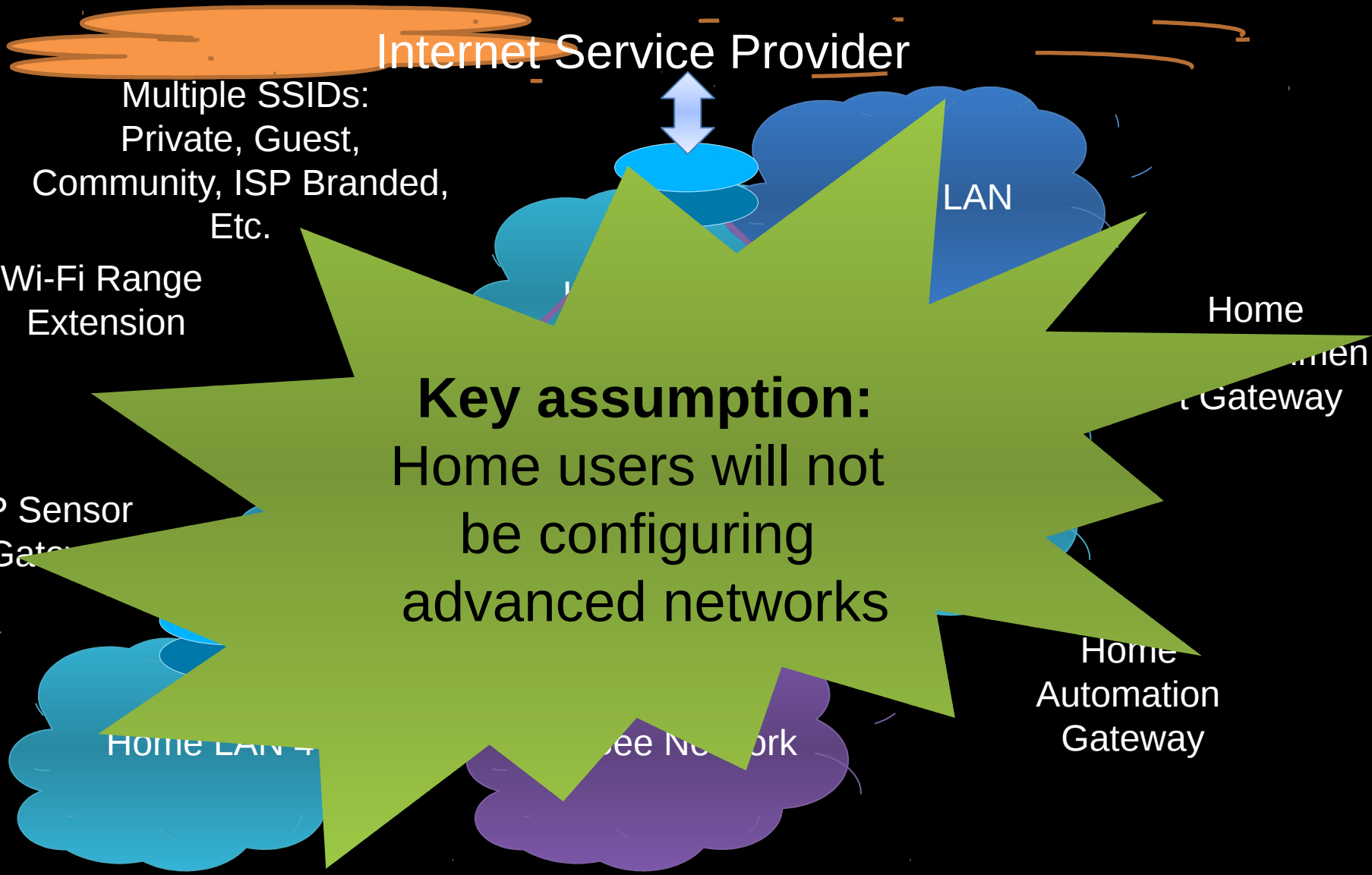IP Sensor
Gate

Key assumption:
Home users will not
be configuring
advanced networks

Home LAN 4

ee Network

Home
Automation
Gateway

HIPnet is a Solution to Complex Home Networks

- A self-configuring home router architecture

  - Capable of operating in increasingly large residential home networks

  - Requires no user interaction for the vast majority of use-cases

  - Uses existing protocols in new ways

  - Does not require a routing protocol

  - Meets the principles of draft-ietf-homenet-arch

Common Principles Guide HIPnet

- Home networks will become more complex, home users will not

- Invoking a god box leads to religious wars

- New protocols bring new problems

- We have enough addresses

- Use IPv6, support IPv4

HIPnet Meets Current Needs
with Existing Functionality

- IPv6 is being deployed today (thankfully)

- Home networks are growing today

- A solution is needed today (or sooner)

  – Based on RFC 6204/bis

- HIPnet works: running code

  – Built on OpenWRT

  – Updates to DHCP

HIPnet Works

- Self-Organizing: Directionless Routers

- Addressing: Recursive Prefix Delegation

- Routing: Hierarchical Routing

- Bonus: Multiple Address Family Support

- Supports arbitrary topologies, multihoming, security, and service discovery…
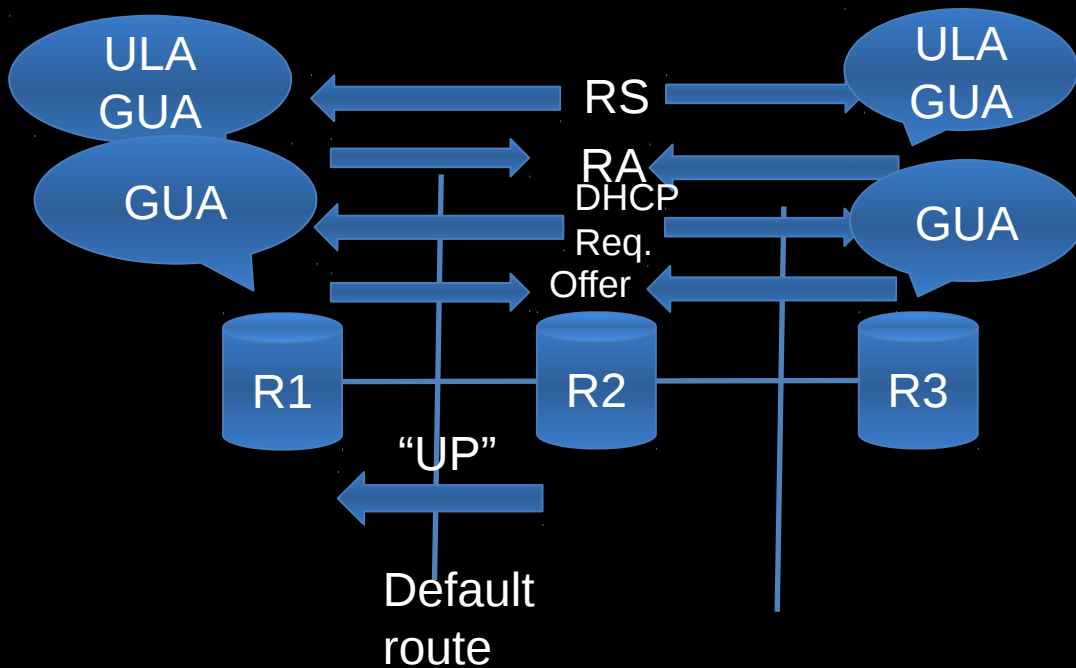
Directionless Home Routers

- The HIPnet router sends Router Solicitations on all interfaces (except Wi-Fi*)

- The router adds any interface on which it receives an RA to the candidate 'up' list

- The router initiates DHCPv6 PD on all candidate 'up' interfaces.

  - If no RAs are received, the router generates a /48 ULA prefix

- The router evaluates the offers received and chooses the winning offer as its Up Interface

Deterministic Up Interface Selection Criteria

- Valid GUA preferred (preferred/valid lifetimes >0)

- Internal prefix preferred over external (for failover - see Section [6.1])

- Largest prefix (e.g. /56 preferred to /60)

- Link type/bandwidth (e.g. Ethernet vs. MoCA)

- First response (wait 1 s after first response for additional offers)
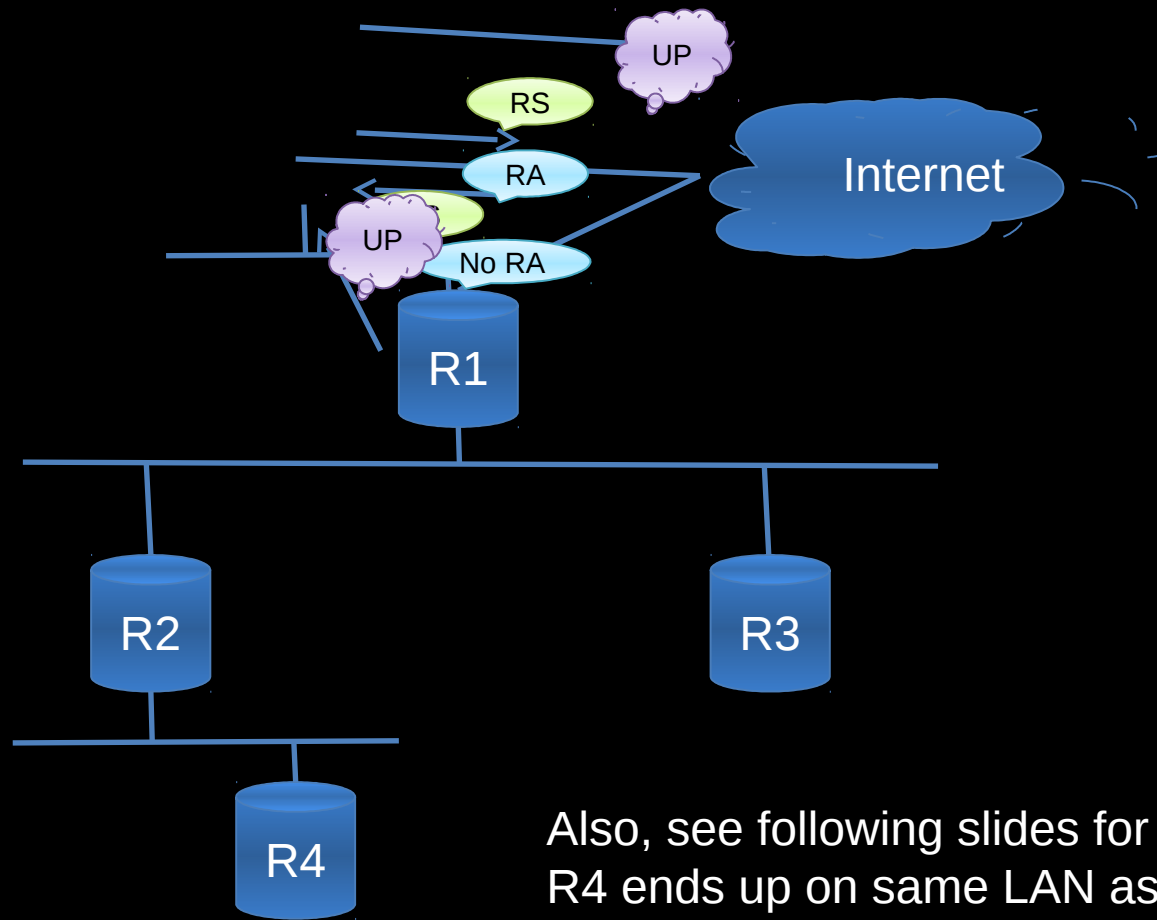
- Lowest numerical prefix

Example Up Detection

More Complicated
Up Detection Example
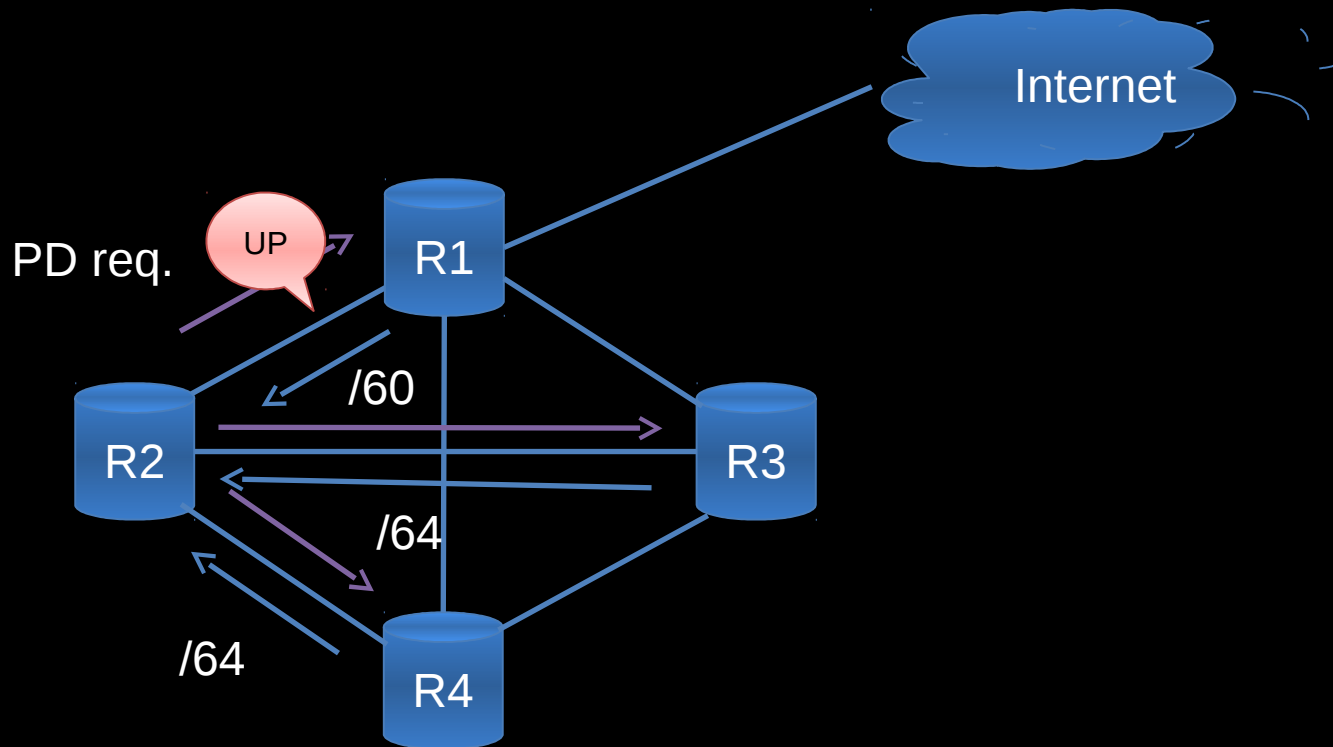
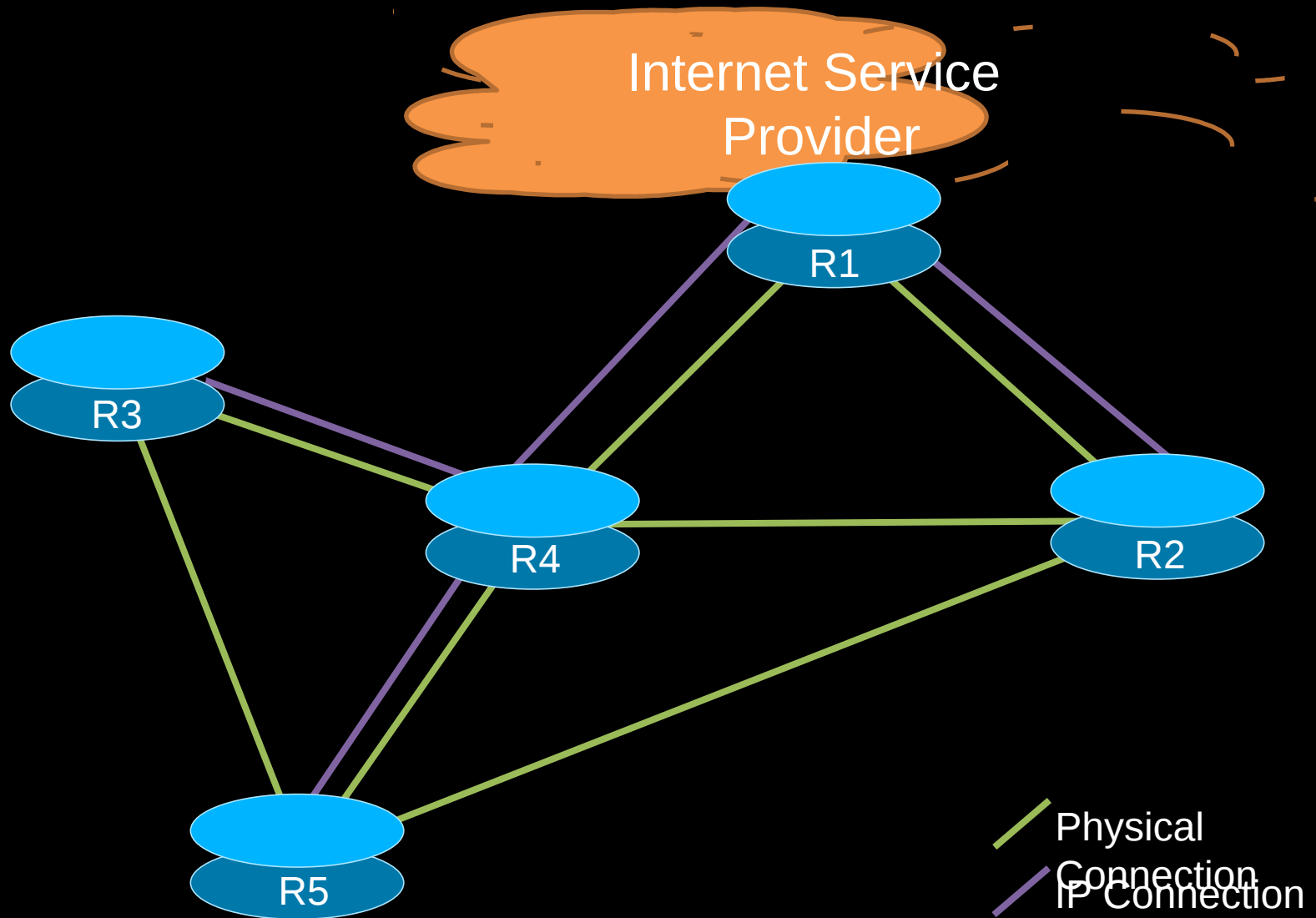# Directionless Routers Example: Rearranging the Network

UP

RS

RA

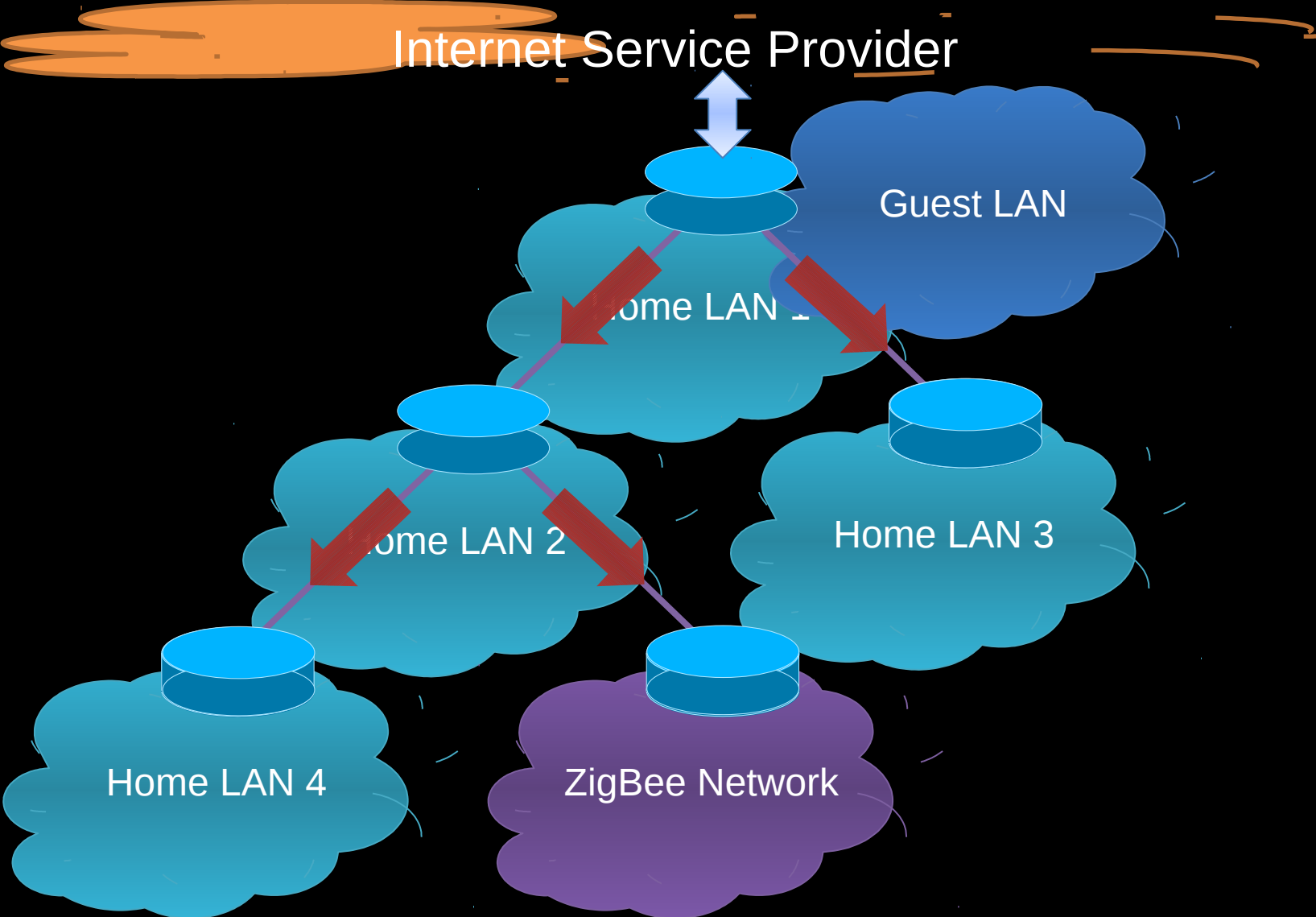Internet

UP

No RA

R1

R2

R3

R4

Also, see following slides for case where R4 ends up on same LAN as R1, R2, R3

HIPnet Creates a Logical Hierarchy from a Physically Arbitrary Network

Recursive Prefix Delegation

Width Optimization

- If the received prefix is smaller than a /56

  - 8 or more port routers divide on 3-bit boundaries (e.g. / 63)

  - 7 or fewer port routers divide on 2-bit boundaries (e.g. / 62)

- If the received prefix is a /56 or larger

  - 8 or more port routers divide on 4-bit boundaries (e.g. / 60)

  - 7 or fewer port routers divide on 3-bit boundaries (e.g. / 59)

Hiearchical Routing Table

Up

::/0 → Default Router

IA_PD → Downstream IR's "Up Interface" IP

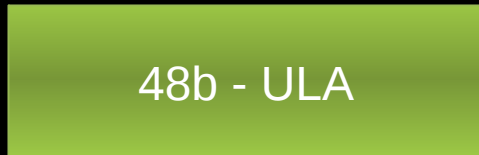**Down**
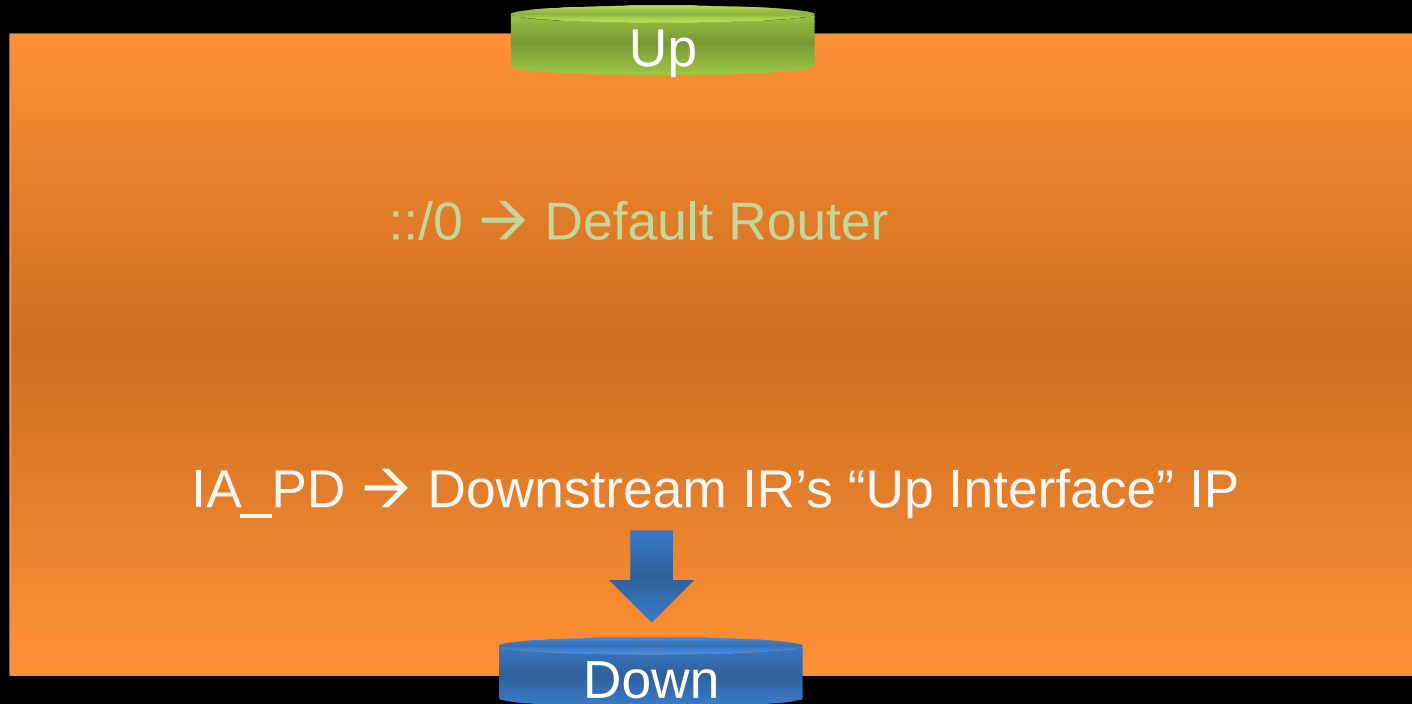
Multiple Address Family Support

- Recursive prefix delegation can be extended to support additional address types

  - ULA, additional GUA, or IPv4

- 8 or 16 bit Link ID extrapolated from IA_PD

  - Bits 56-64 or 48-64

- Additional prefixes are prepended to Link ID

  - Additional prefixes extrapolated from RA or DHCPv4 on Up Interface

Link ID

48b - ISP	16b – Link ID	64b – Interface ID

48b - ULA		/64

IPv4 "10."		/24

Multihoming Use-Cases

- Special purpose IP connection (e.g. IP Video)

- Backup connection (i.e. active/standby)

- "True" multihoming (i.e. active/active)

  (Info in backup slides)

The HIPnet Solution

- Directionless Home Routers

  - Up Detection creates logical hierarchy

- Recursive Prefix Delegation

  - Link ID allows multiple address families

- Hierarchical Routing

  - Determinism without a routing protocol

- The next step in home networking!

Questions?

@ChrisGrundemann
chris@chrisgrundemann.com
http://chrisgrundemann.com

Backup Slides

Appendix

Recursive Prefix Delegation

- Based on DHCPv6 prefix delegation

  - [RFC3633](#)

- Inspired by a "Simple Approach to Prefix Distribution in Basic Home Networks"

  - [draft-chakrabarti-homenet-prefix-alloc](#)

- HIPnet router receives prefix in IA_PD, breaks it up, and hands it out

HIPnet Addressing Details

- The HIPnet router acquires a prefix and then breaks it into sub-prefixes

- The first of these sub-prefixes is further broken into /64 interface-prefixes for use one on each of the router's down interfaces

  - If the sub-prefix is too small to number all down interfaces, the router uses additional sub-prefixes as needed (in numerical order)

  - If the aggregate prefix is too small to number all down interfaces, the router collapses them into a single IP interface, assigns a single /64 to that interface

- The remaining sub-prefixes are delegated via DHCPv6 to directly downstream routers as needed, in reverse numerical order

Hierarchical Routing

- The HIPnet router installs a single default 'up' route and a more specific 'down' route for each prefix delegated to a downstream IR

- 'down' routes point all packets destined to a given prefix to the WAN IP address of the router to which that prefix was delegated

- No routing protocol needed!

Multihoming Use-Cases

- Special purpose IP connection (e.g. IP Video)

- Backup connection (i.e. active/standby)

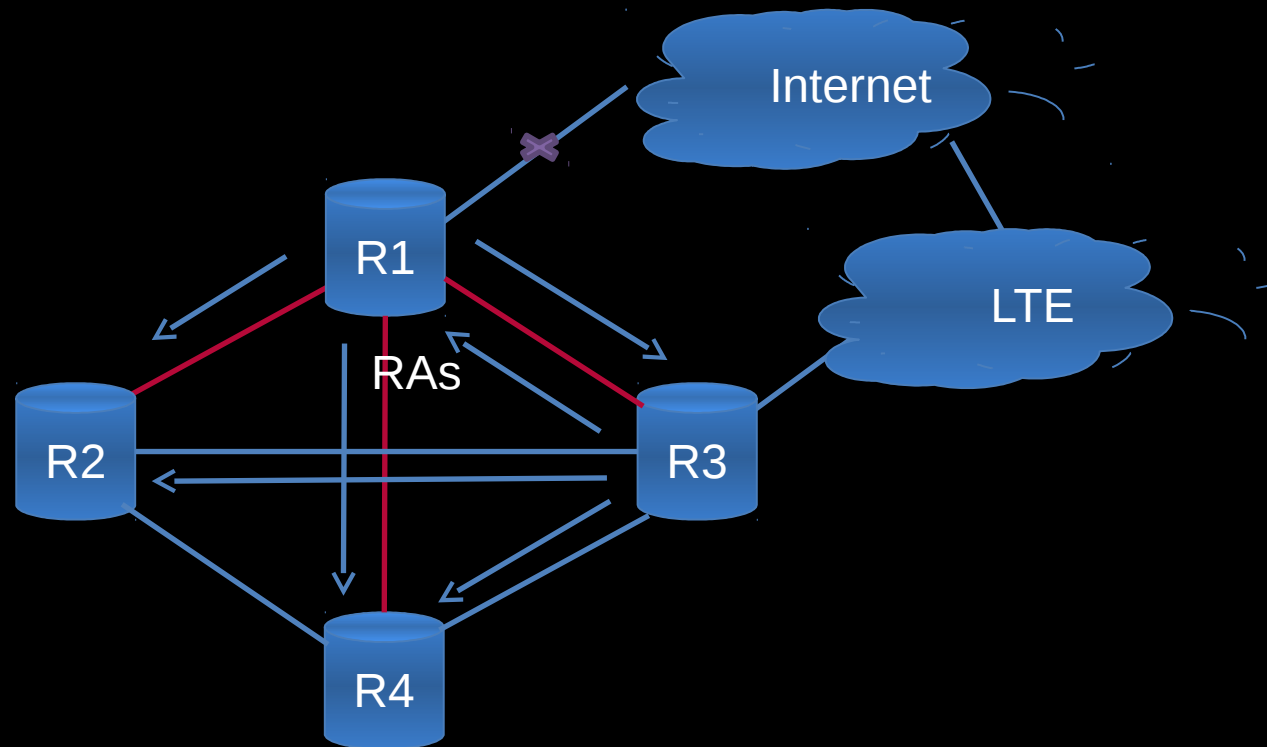- "True" multihoming (i.e. active/active)

Special Purpose IP Connection

- IP video or other non-Internet connection

- Some configuration allowed
  - User or technician configured
  - Managed or semi-managed

- Automated / configurationless
  - Has been discussed
  - Outside of current scope
  - May be included in future versions of HIPnet

Backup Connection

- Active/standby with failover

- Default HIPnet use-case

- Internal prefix preferred in Up detection

  – First CER to come online is primary

  – Backup CER doesn't announce its prefix

  – Upon failure of primary, secondary CER announces its prefix (becomes primary), tree is re-built

  – Backup judges failure based on:

  – Timeout (primary CER stops advertising GUA)

  – Preferred, valid, & router lifetimes from primary set to 0

Backup Network – Example

Multihoming

- Active/Active with load sharing

- Possible under HIPnet architecture

- "Shared tree"
  - Primary CER (first active) builds hierarchical tree
  - Secondary CER adds its prefix to existing tree
  - Secondary can be same level (full multihoming) or lower level (VPN use-case)
 - Requires NAT or source routing at CERs

Multihoming Algorithm

- CER performs prefix sub-delegation as described earlier
  - hierarchical tree network
- Secondary CER (R4) obtains second prefix from ISP2
  - Advertises ISP2 prefix as part of RA
  - Includes sub-prefixes from both ISPs in IA_PD (same "link id")
- Secondary CER points default route to ISP2, internal /48 route to upstream internal router (e.g. R1)
- Devices below R4 (e.g.R3, R5) use ISP2, but have full access to all internal devices using ISP1 prefix or ULAs
  - If ISP2 link fails, traffic flows to ISP1
- Devices not below R4 (e.g. R1, R2) use ISP1, but have full access to all internal devices using ISP1 prefix or ULAs
- Potential optimization - CER source routing – default route selected based on packet Source IP address

Multihoming Network Example
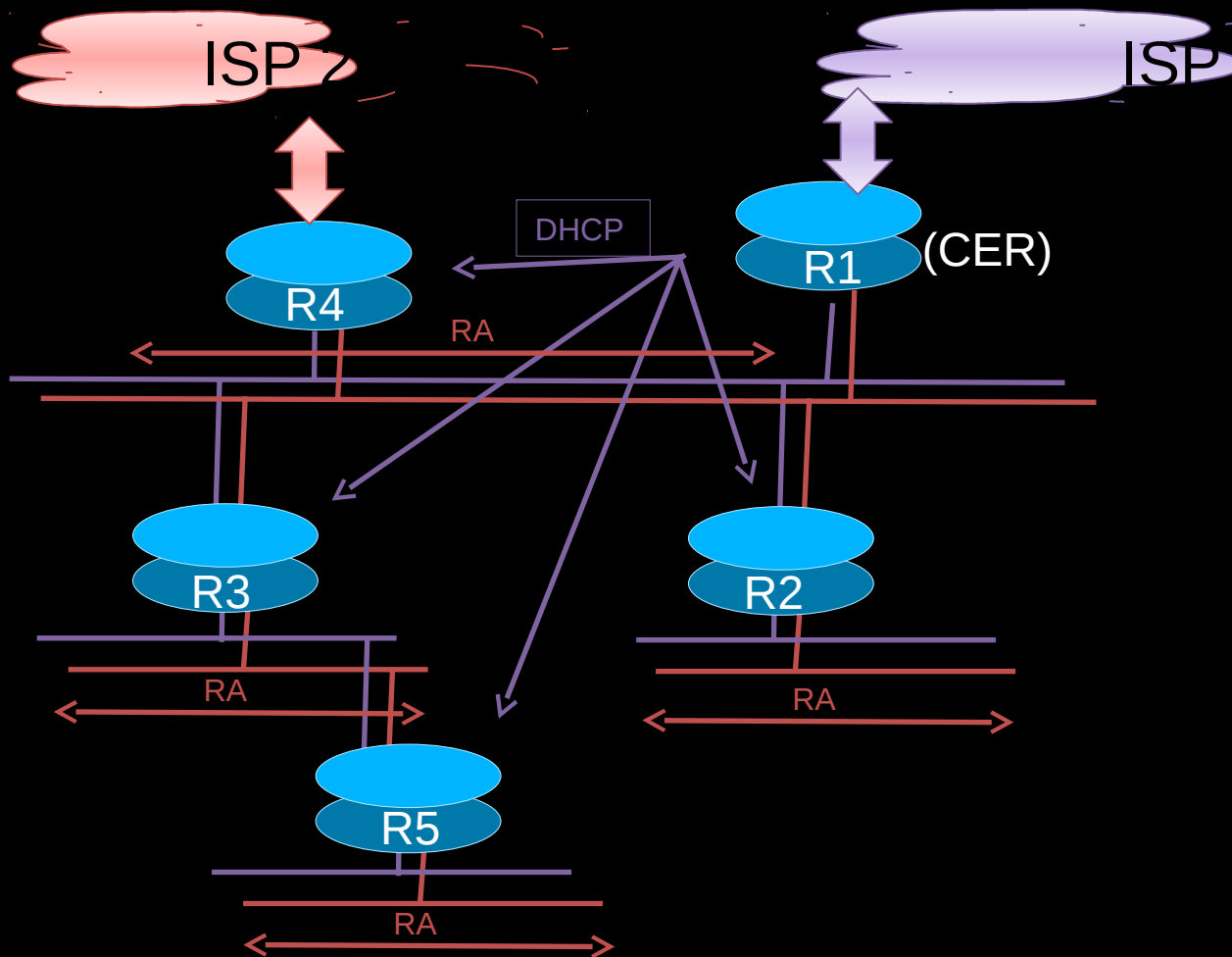
VPN Multihoming Example

Internet

ISP 2

R1

R2

R4

R3

R5
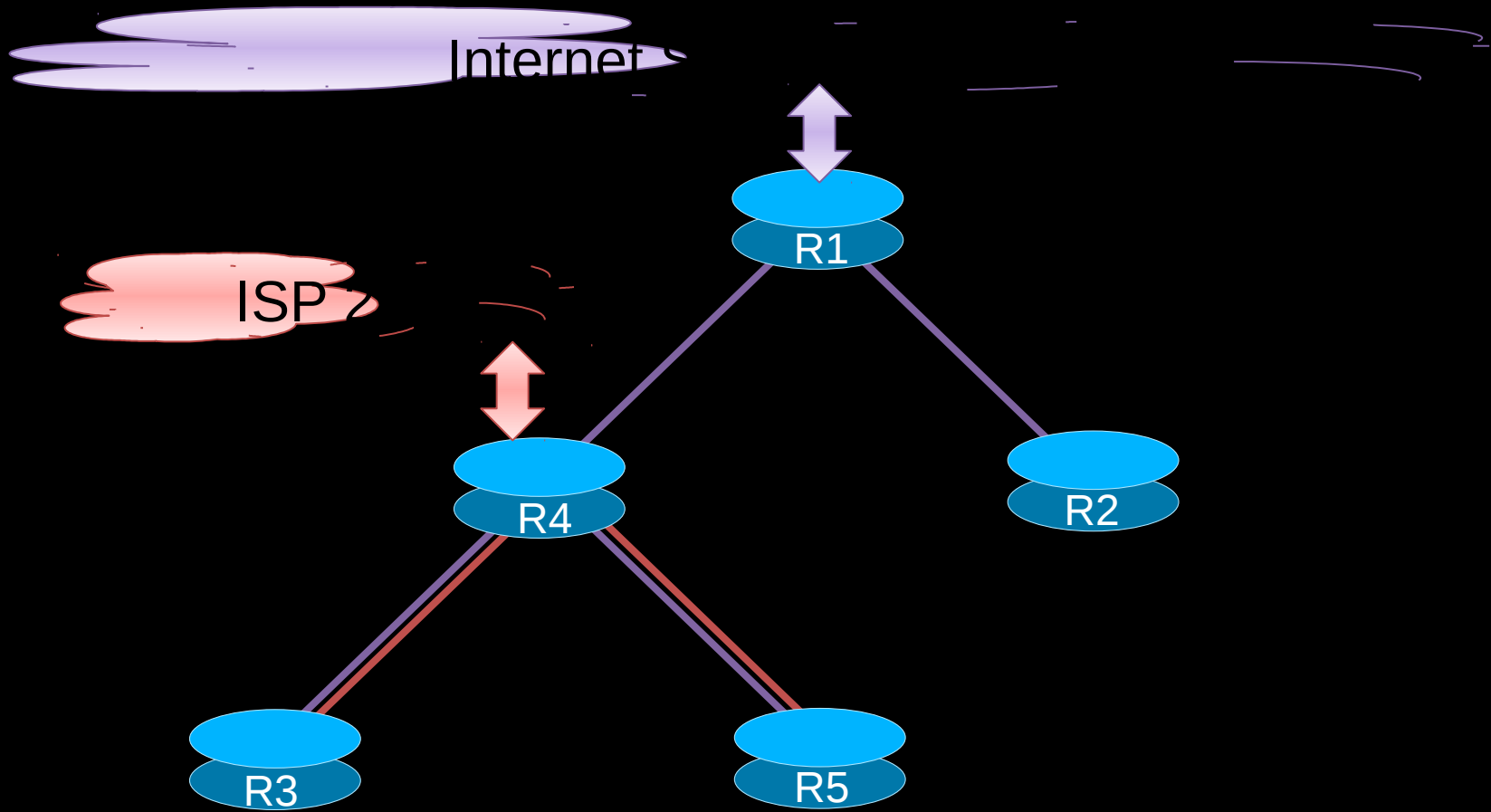
Multihoming FAQ

- What if the PD sizes from ISP1 and ISP2 are different?
  - The hierarchy determined by DHCP (ISP1 in the example)
  - Clarifying rule: routers MUST NOT act as DHCP client and server on same link.
- What if the L2 router picks the wrong L1 for default traffic?
  - The wrong L1 forwards it to the right L1
- What if we don't use the PD algorithm discussed above?
  - Not guaranteed to work
  - Routers only receive PD from one DHCP server
  - Would require mechanism for sending ISP2 PD to the CER

Multicast Requirements

- HIPnet routers support service discovery through multicast forwarding
- Simple rules:
  - MULTI-1: A HIPnet router MUST discard IP multicast packets that fail a Reverse Path Forwarding Check (RPFC).
  - MULTI-2: A HIPnet router that determines itself to be at the edge of a home network (e.g. via CER_ID option, /48 verification, or other mechanism) MUST NOT forward IPv4 administratively scoped (239.0.0.0/8) packets onto the WAN interface.
  - MULTI-3: HIPnet Routers MUST forward IPv4 Local Scope multicast packets (239.255.0.0/16) to all LAN interfaces except the one from which they were received.
  - MULTI-4: A HIPnet router that determines itself to be at the edge of a home network (e.g. via CER_ID option, /48 verification, or other mechanism) MUST NOT forward site-scope (FF05::) IPv6 multicast packets onto the WAN interface.
  - MULTI-5: HIPnet routers MUST forward site-scoped (FF05::/16) IPv6 multicast packets to all LAN interfaces except the one from which they were received.
  - MULTI-6: A home router MAY discard IP multicast packets sent between Down Interfaces (different VLANs).
  - MULTI-7: HIPnet routers SHOULD support an IGMP/MLD proxy, as described in [RFC4605].

Security & NAT Requirements

- SEC-1: The CER MUST enable a stateful [[RFC6092](#)] firewall by default.

- SEC-2: HIPnet routers MUST only perform IPv4 NAT when serving as the CER.

- SEC-3: By default, HIPnet routers SHOULD configure IPv4 firewalling rules to mirror IPv6.

- SEC-4: HIPnet routers serving as CER SHOULD NOT enable UPnP IGD ([[UPnP-IGD](#)]) control by default.

IR Security Options

- Filtering Disabled

- Simple Security + PCP

- Advanced Security [I-D.vyncke-advanced-ipv6-security]