A Near Term Solution for Home IP networking (HIPnet)

draft-grundemann-homenet-hipnet

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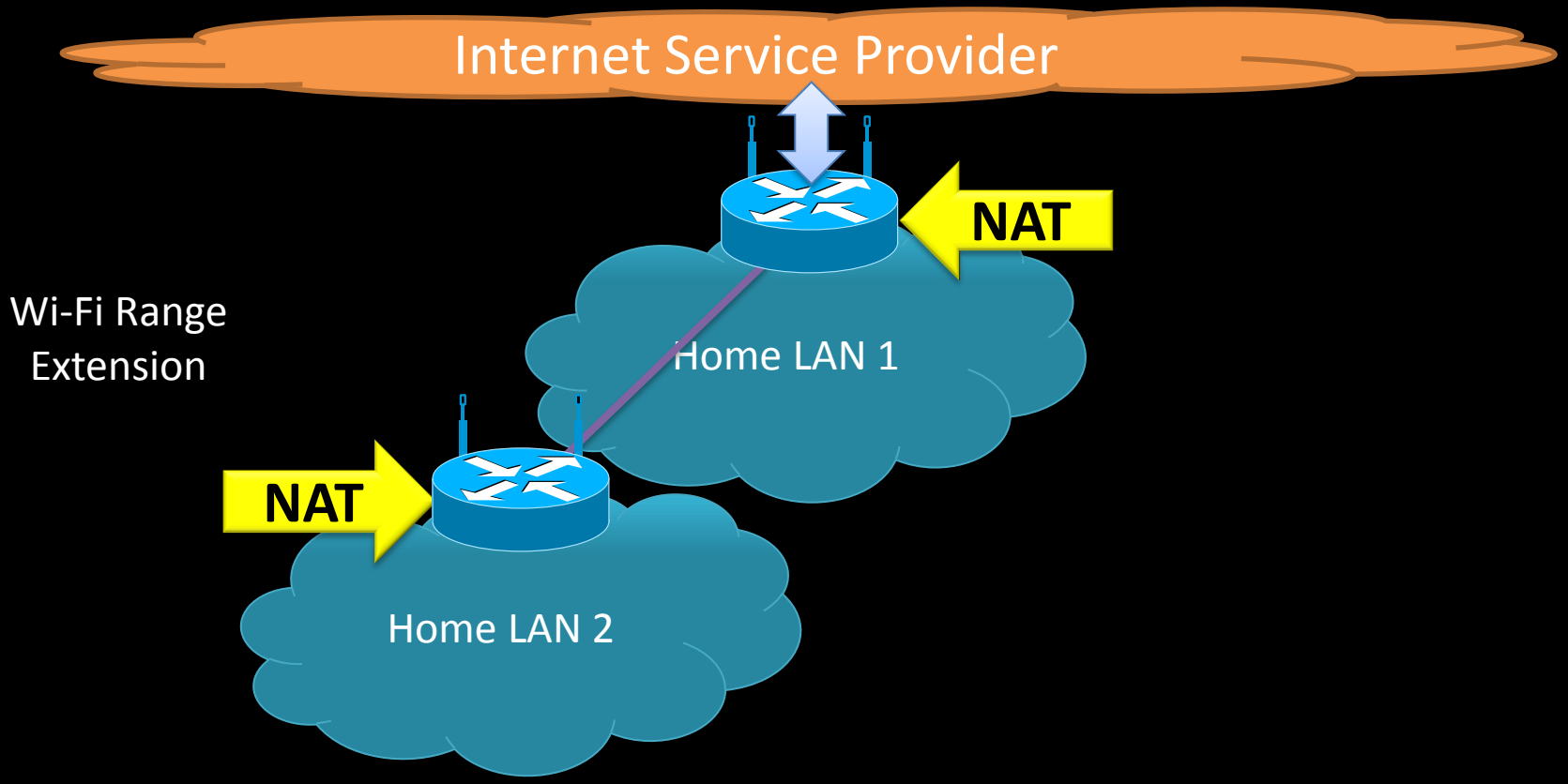
Chris Grundemann, Chris Donley,
John Brzozowski, Lee Howard, Victor Kuarsingh

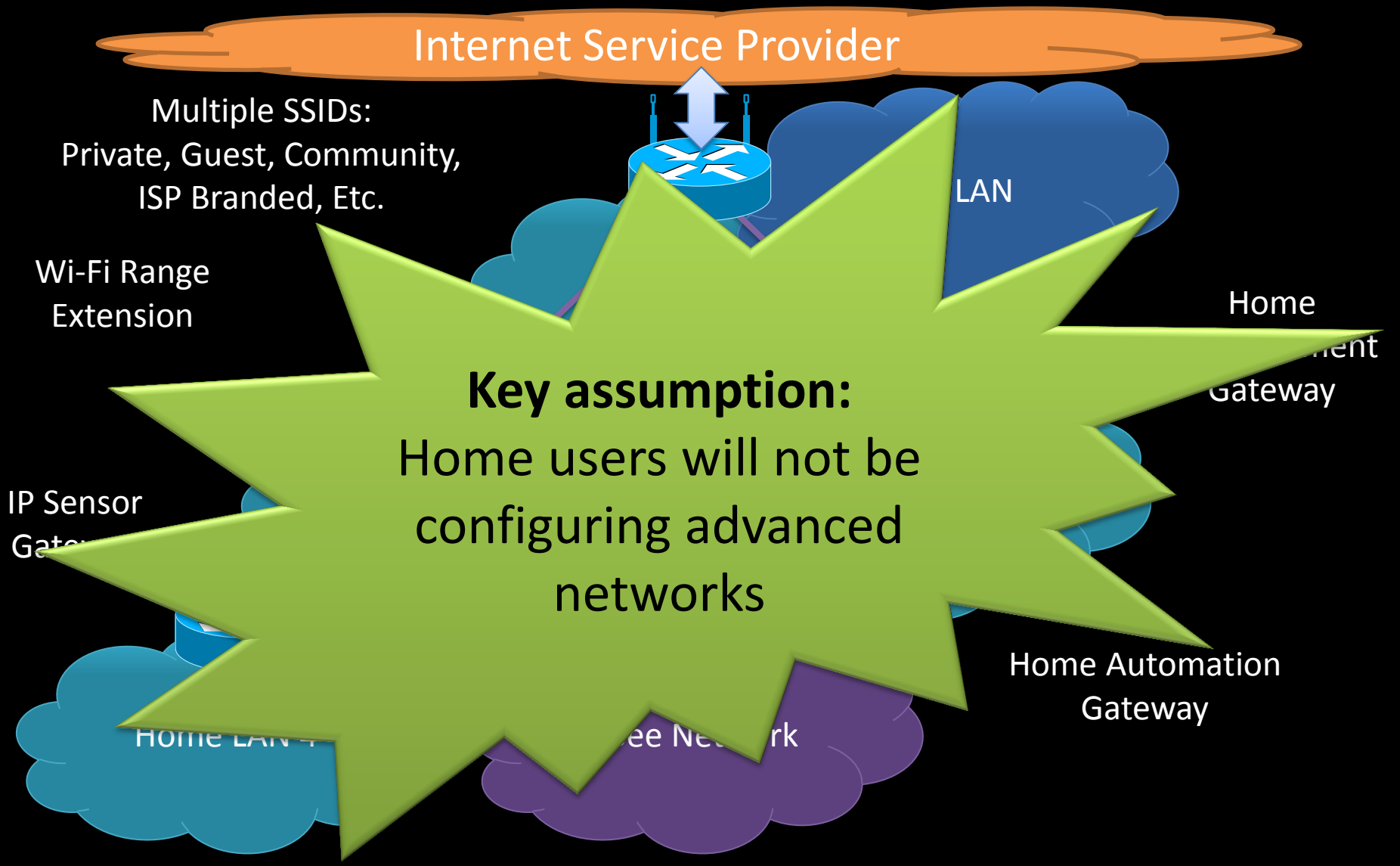
Yesterday's Home Network



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



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…

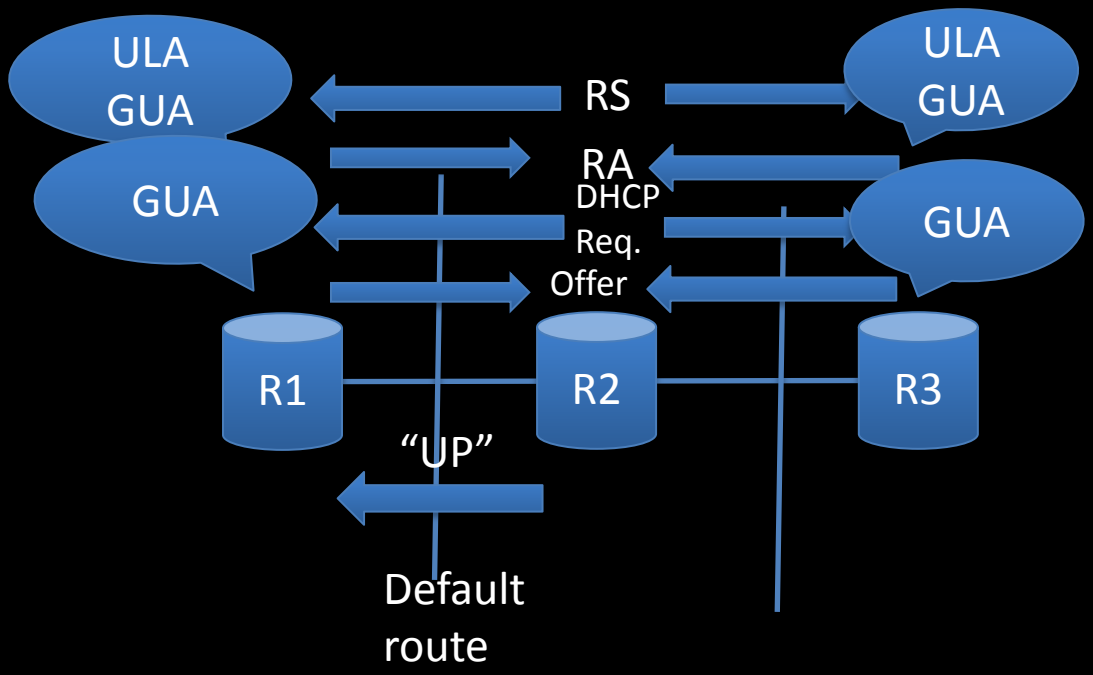
Directionless Home Routers

- 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

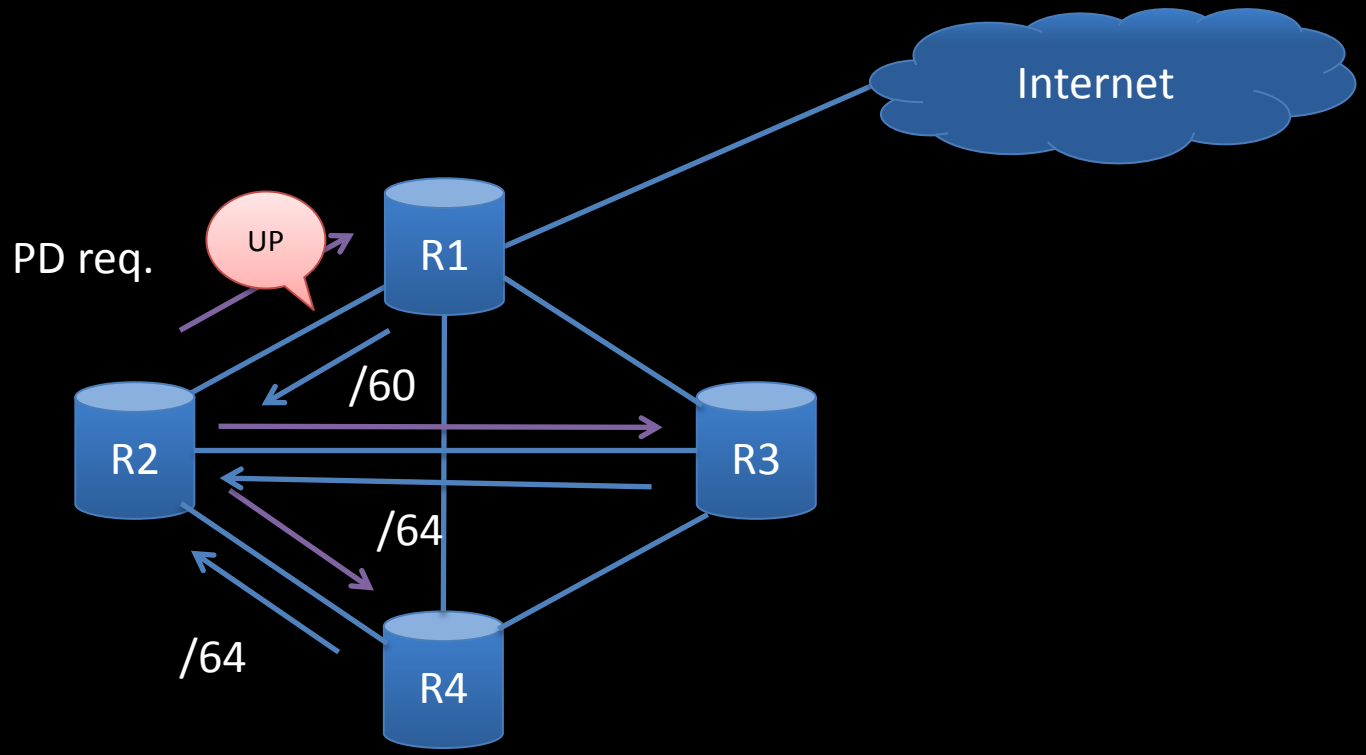
Deterministic Up Interface Selection Criteria

- 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

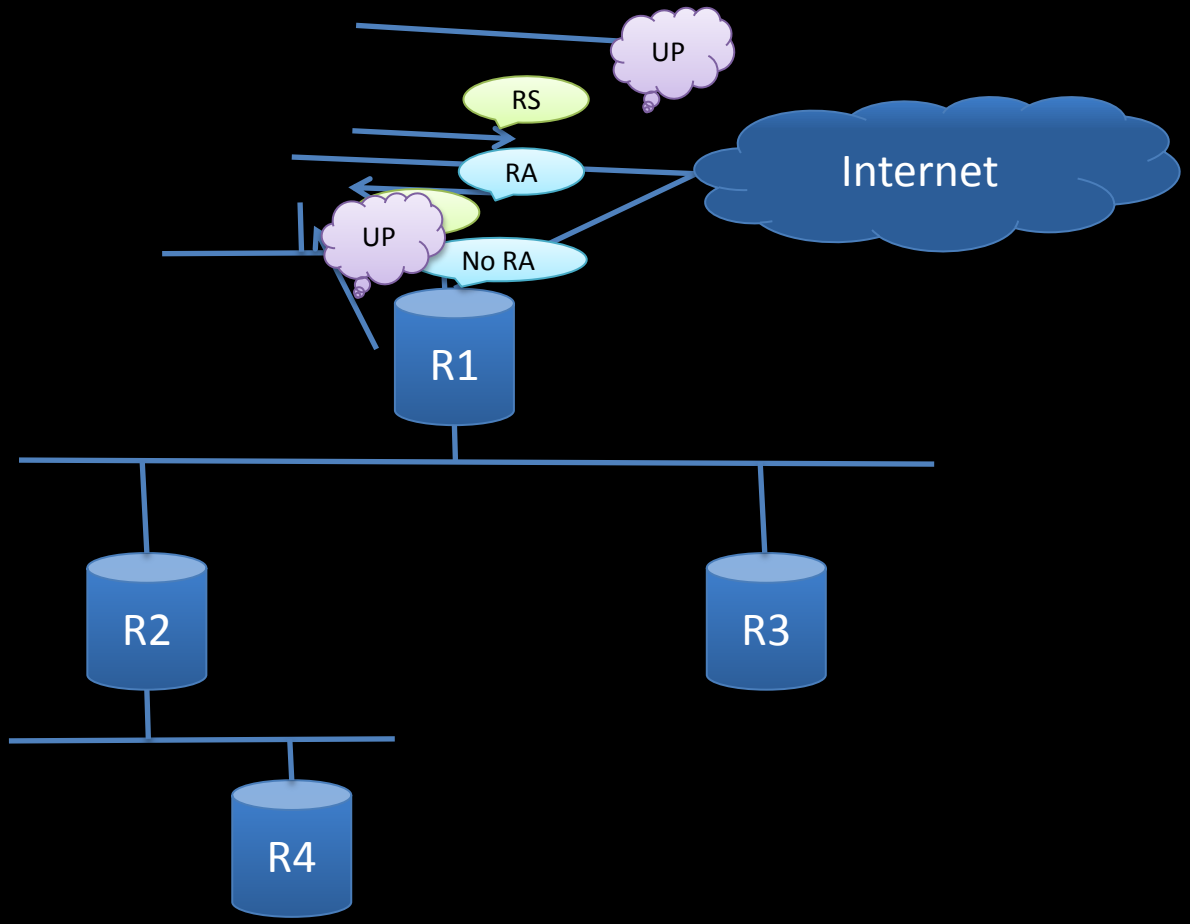
Example Up Detection



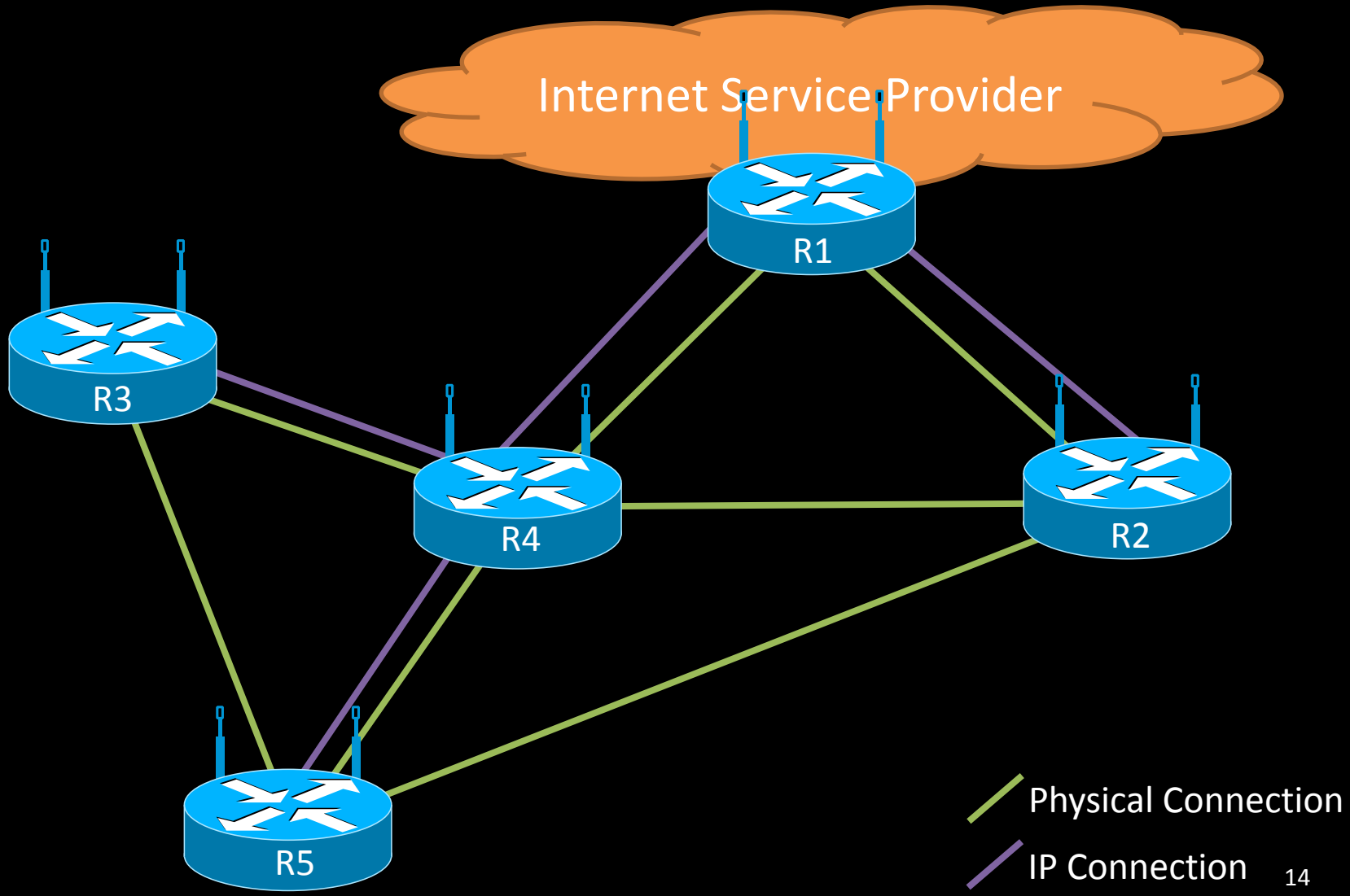
More Complicated Up Detection Example



Directionless Routers Example: Rearranging the Network



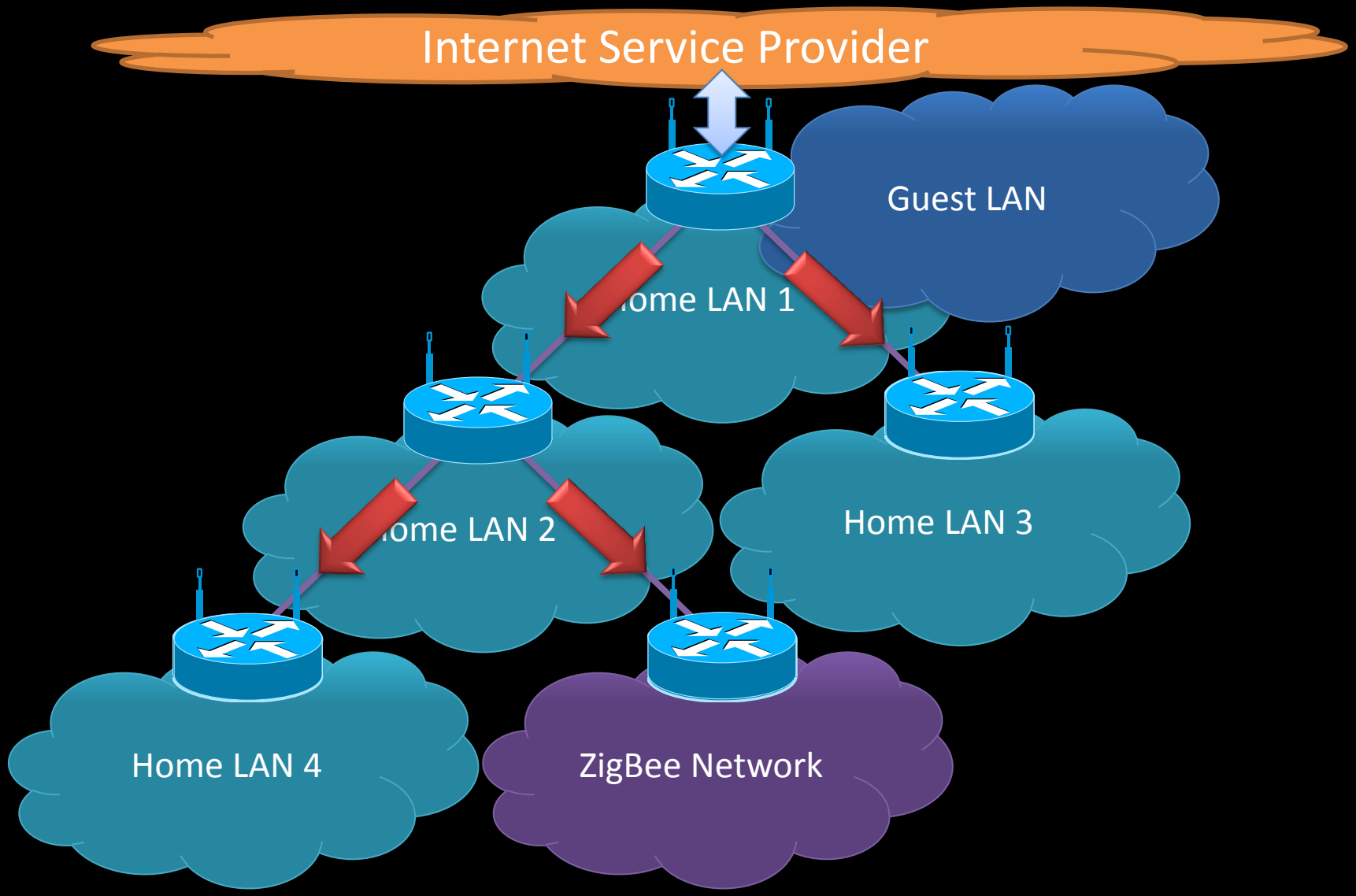
HIPnet Creates a Logical Hierarchy from a Physically Arbitrary Network



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

Recursive Prefix Delegation



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

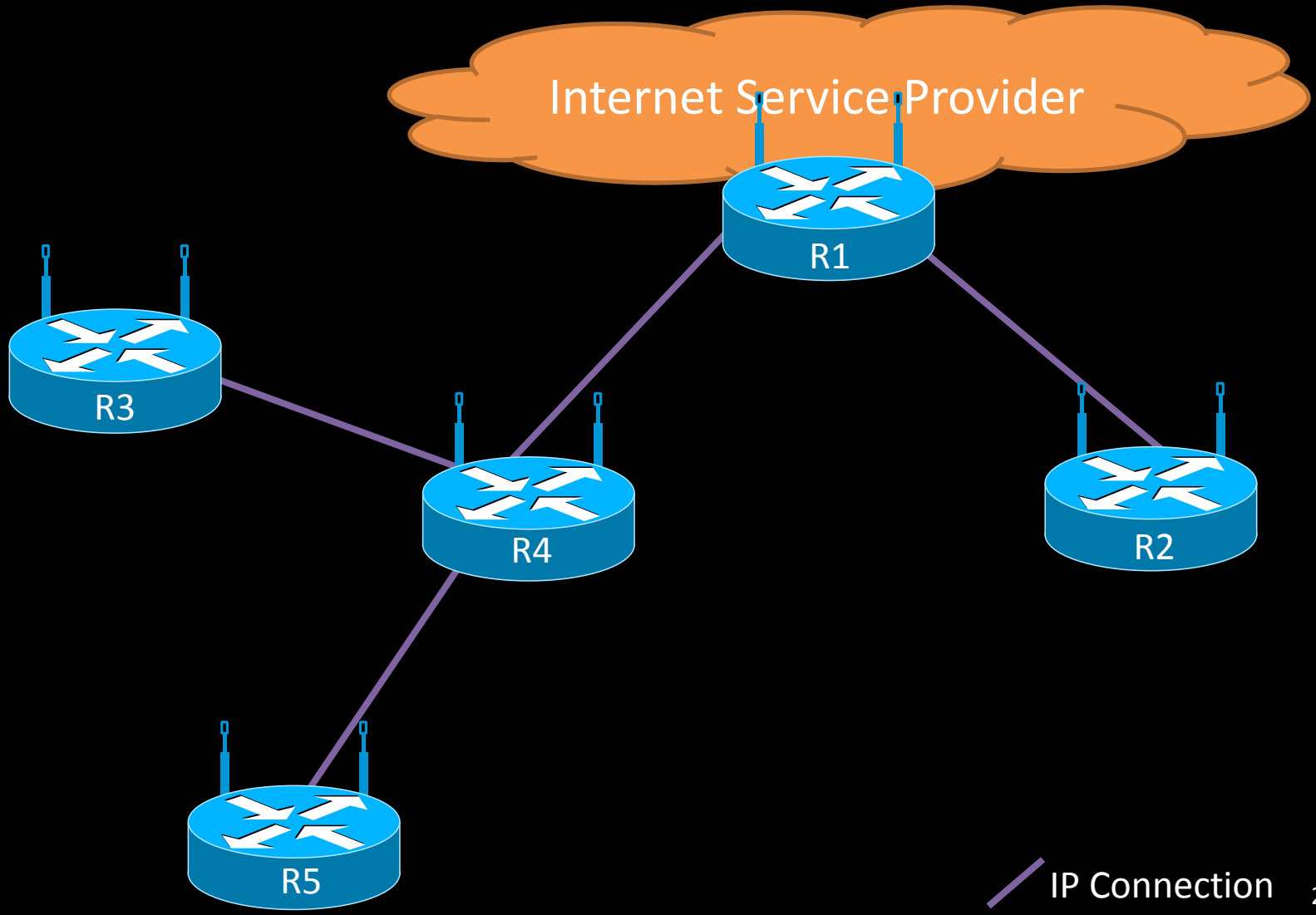
Width Optimization

- 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)

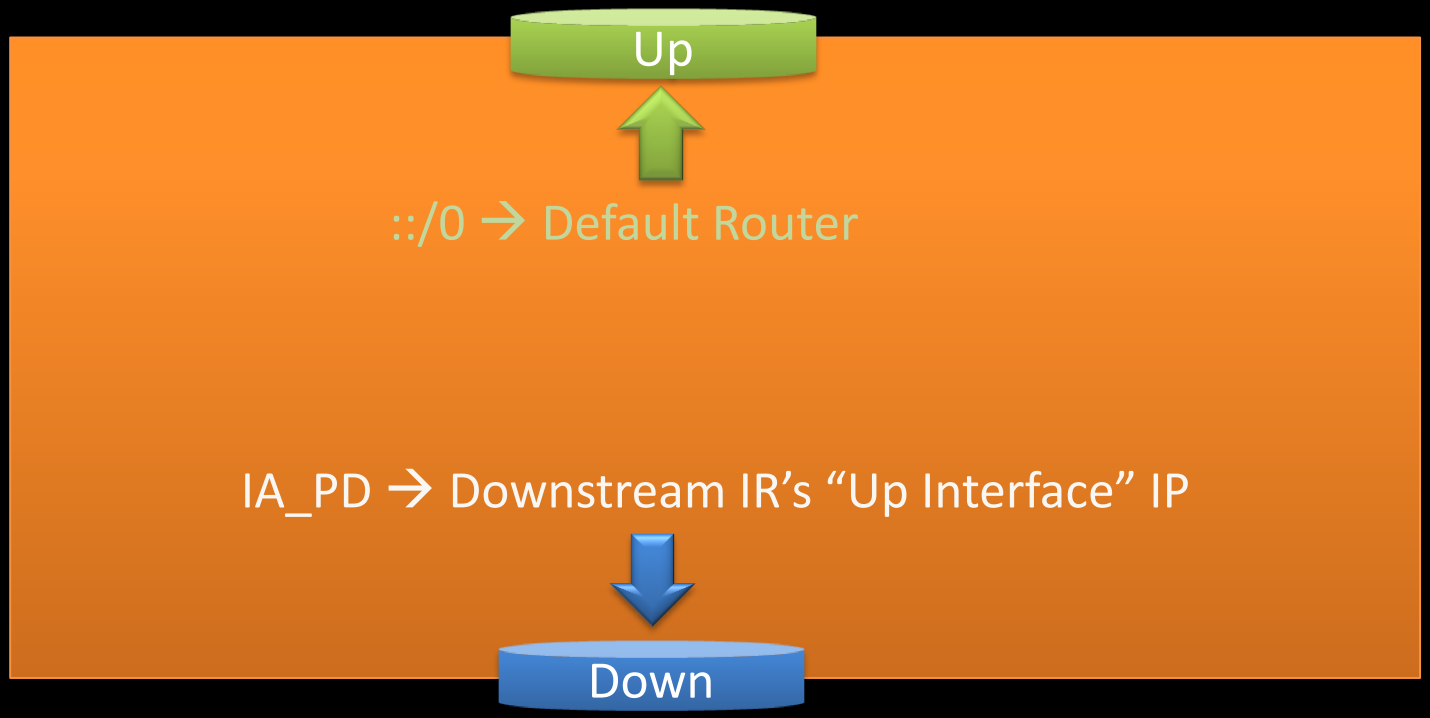
Hierarchical Routing

- 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!

HIPnet Creates a Logical Hierarchy from a Physically Arbitrary Network



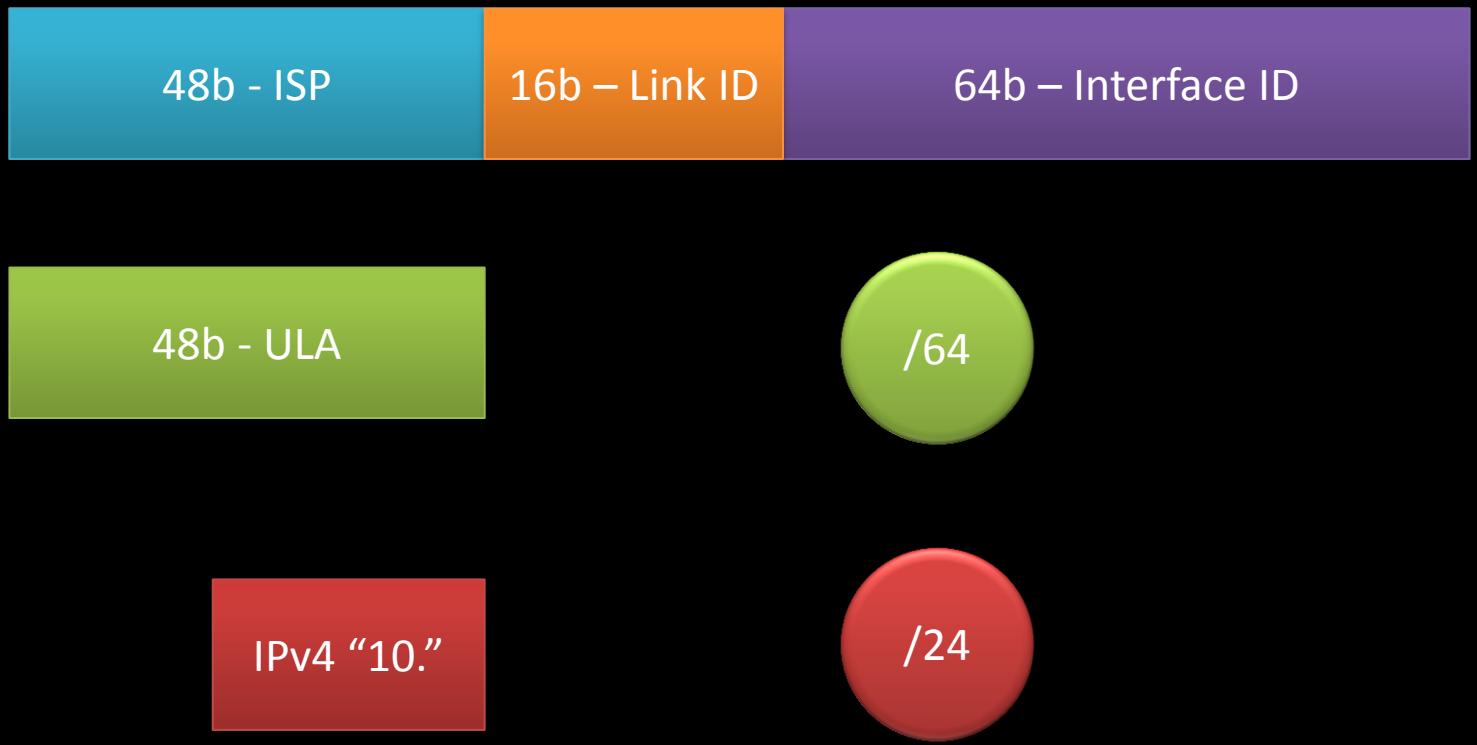
Hiearchical Routing Table



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



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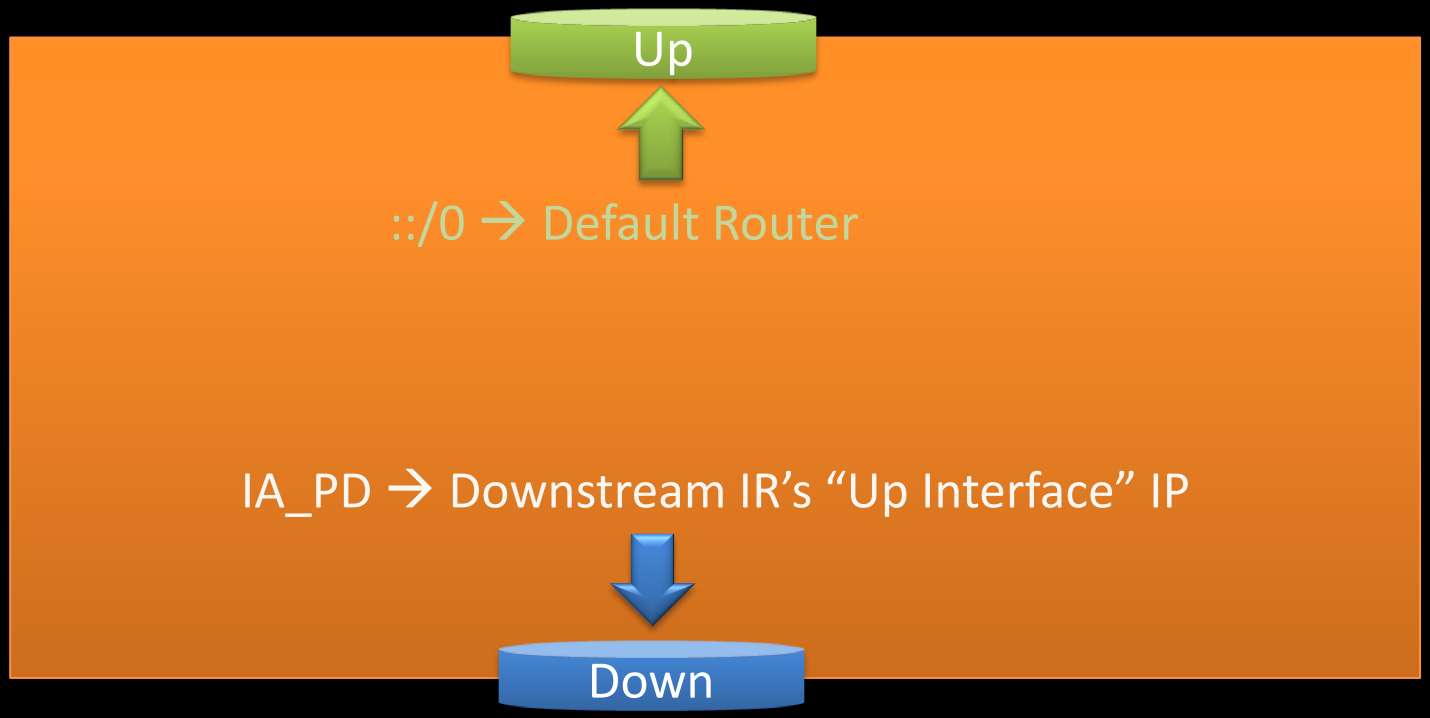


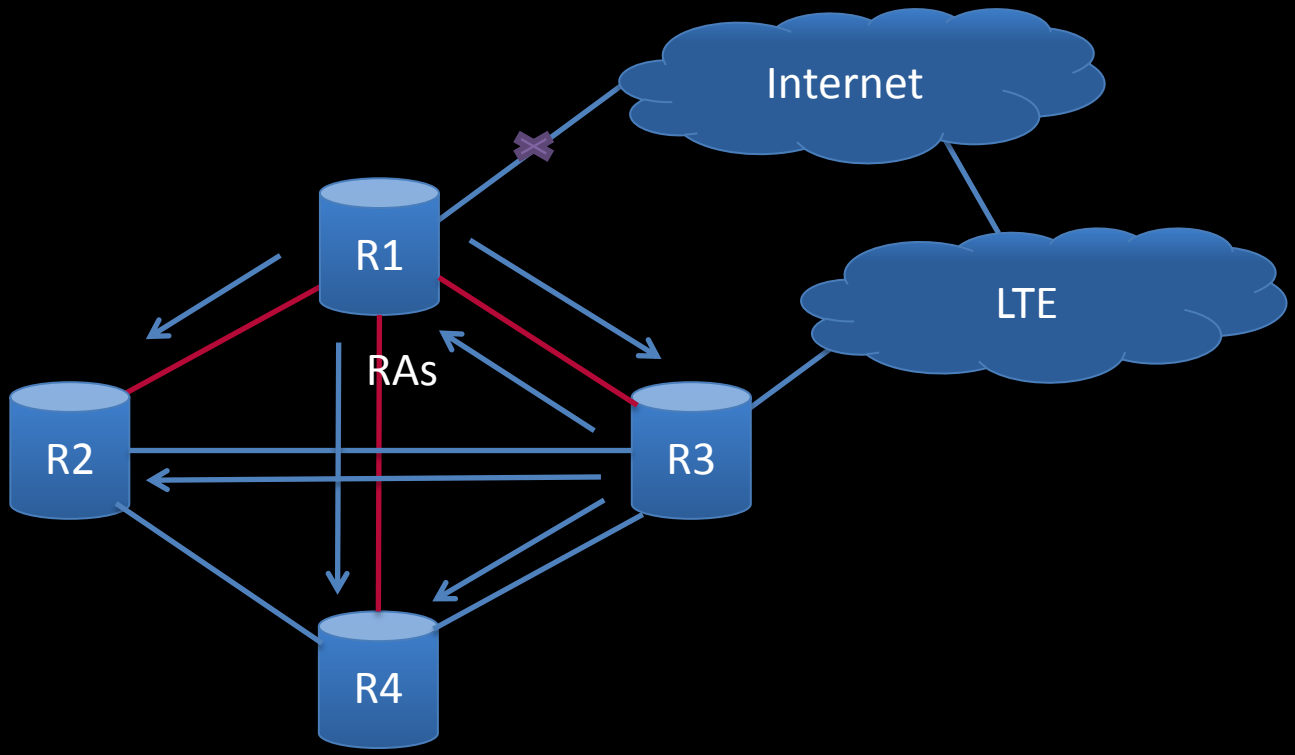
Multihoming Use-Cases

- Special purpose IP connection (e.g. IP Video)
- Backup connection (i.e. active/standby)
- “True” multihoming (i.e. active/active)

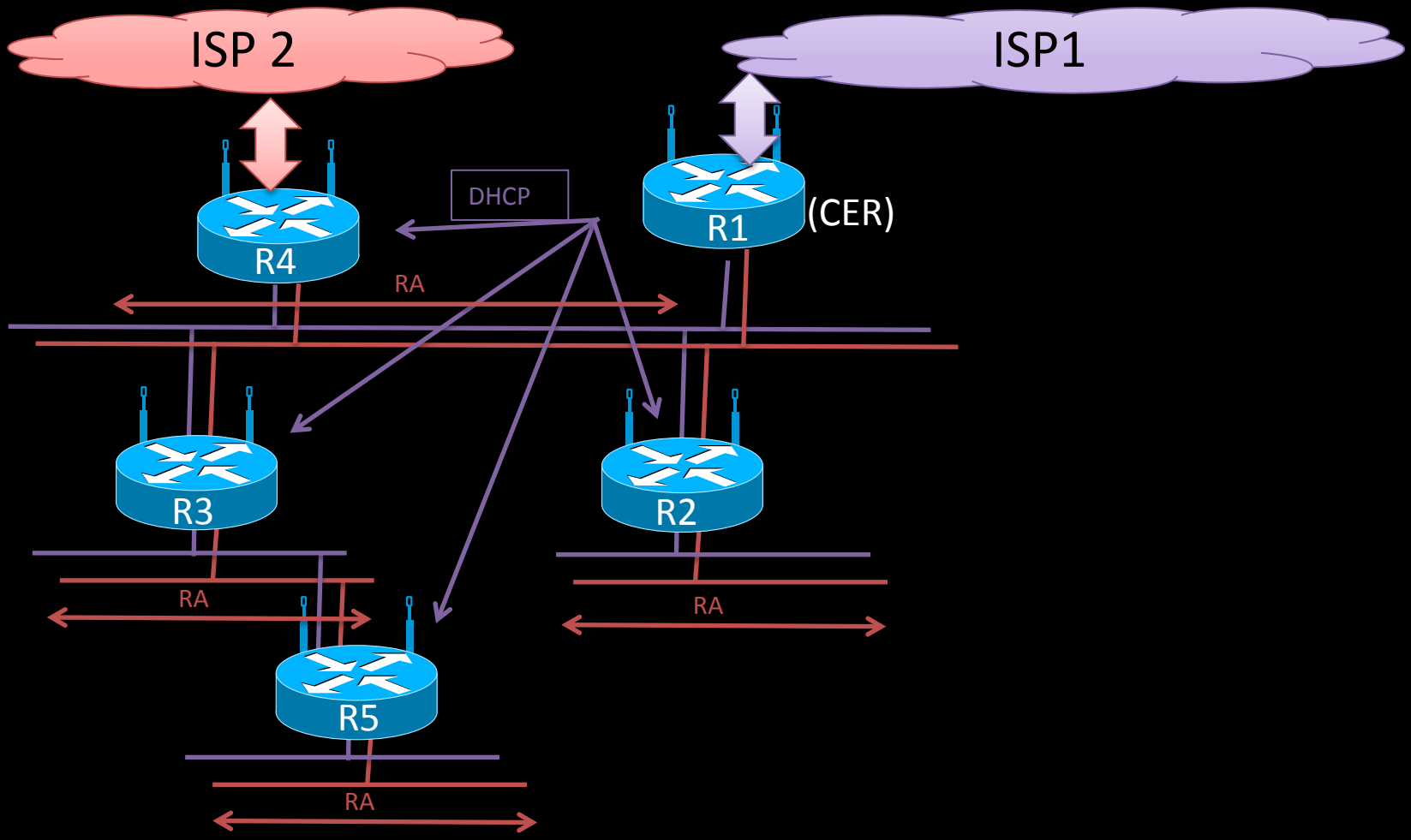
Special Purpose IP Connection

- 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

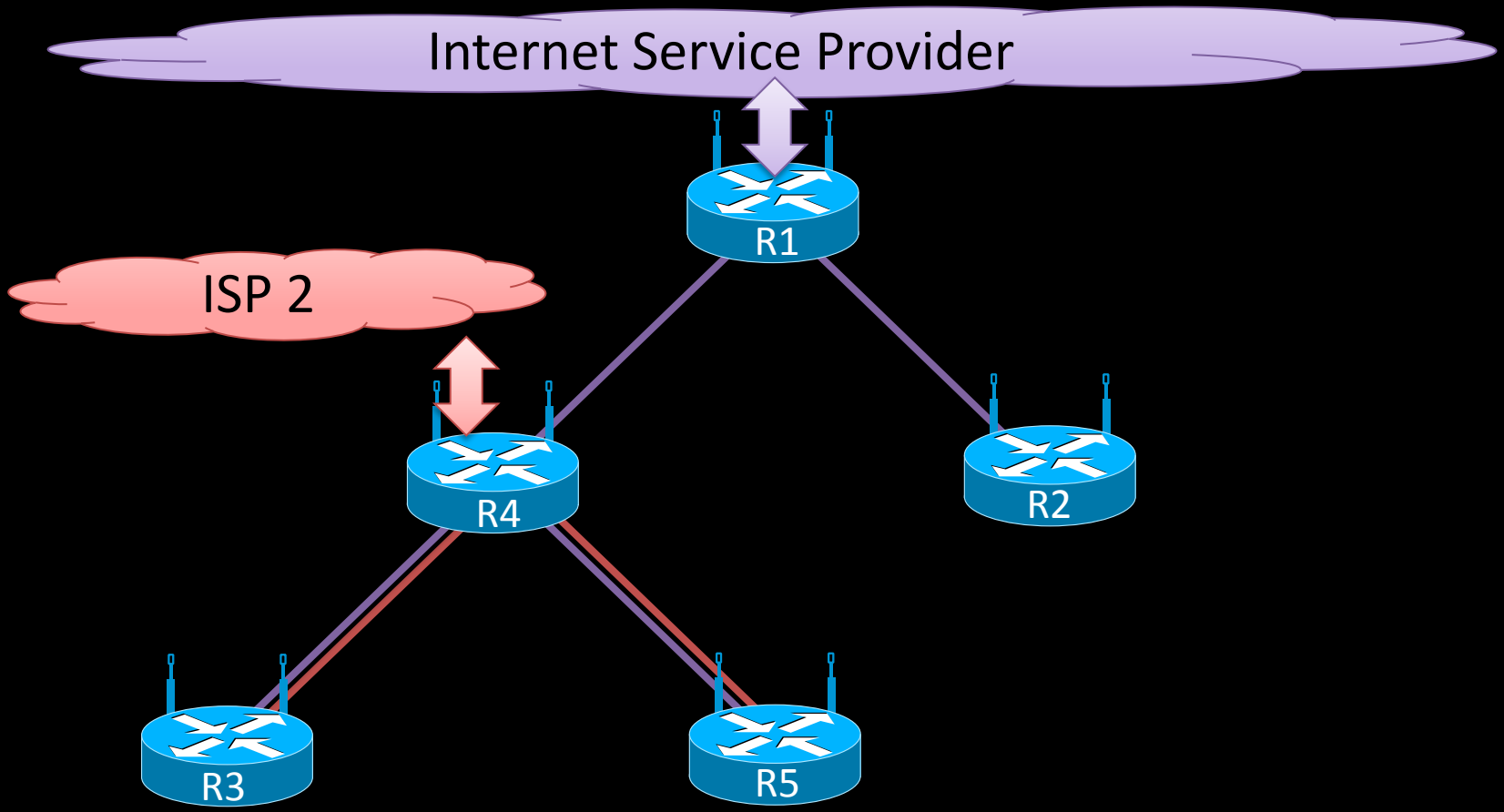
Backup Network – Example



Multihoming Network Example



VPN Multihoming Example



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]

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

Questions?

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

Backup Slides

APPENDIX

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

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 FAQ

- What if the PD sizes from ISP1 and ISP2 are different?
  - The hierarchy is 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].