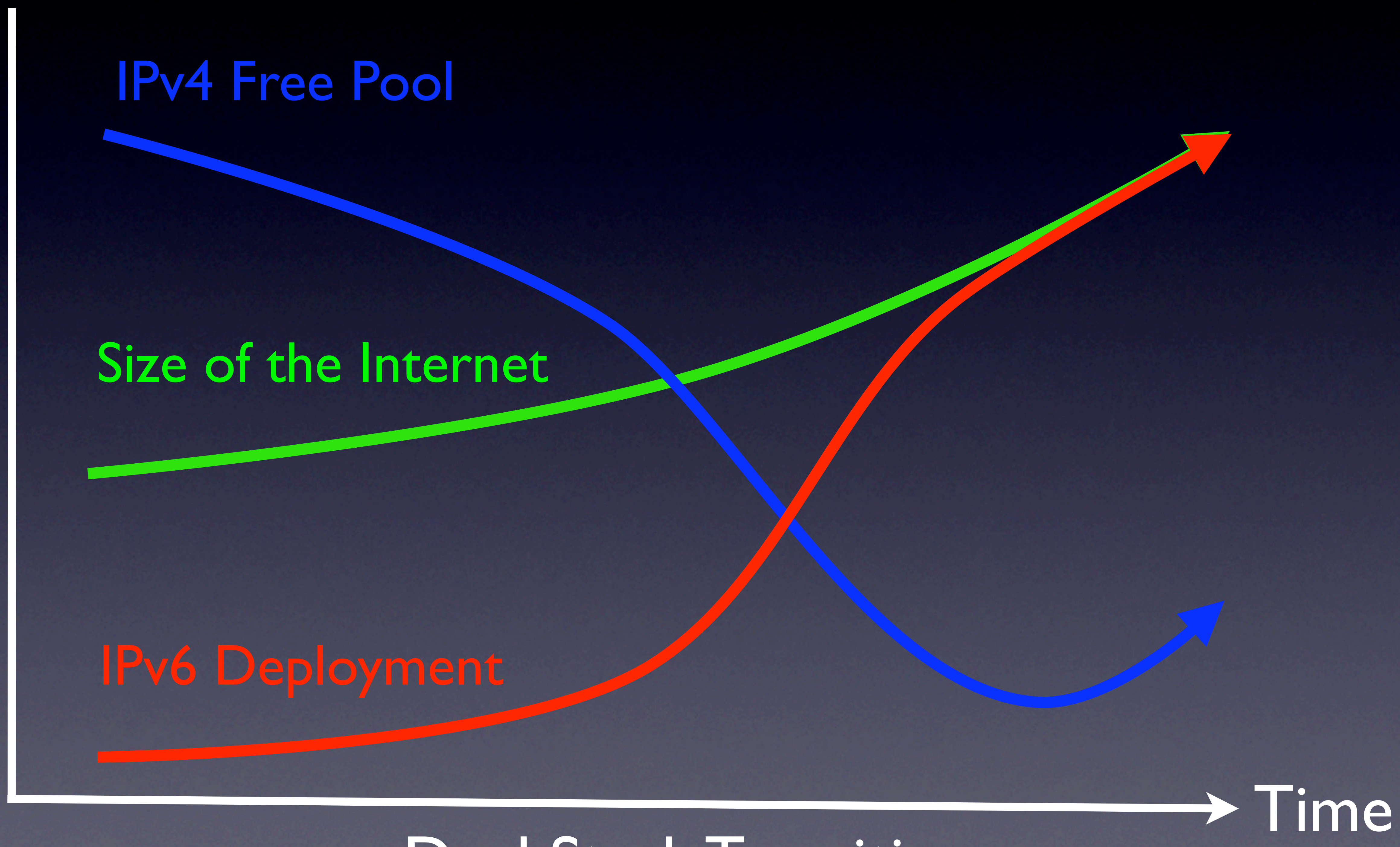
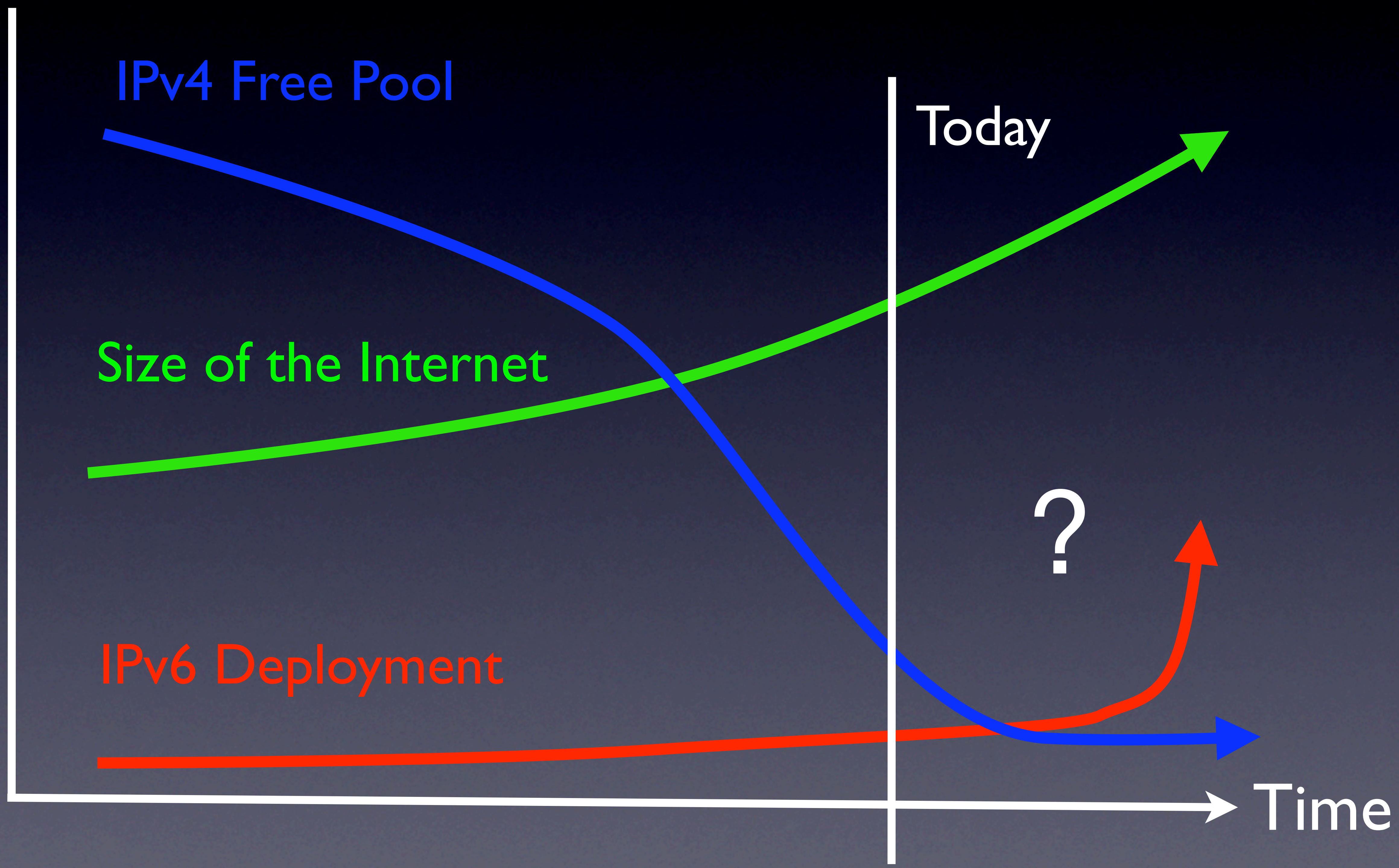
The Plan



Dual Stack Transition

The Reality


IPv4 Free Pool
Today
Size of the Internet
?
IPv6 Deployment
Time

Two Problems

1. Global IPv4 address depletion
2. Private IPv4 address depletion

“depletion” a.k.a. “completion”

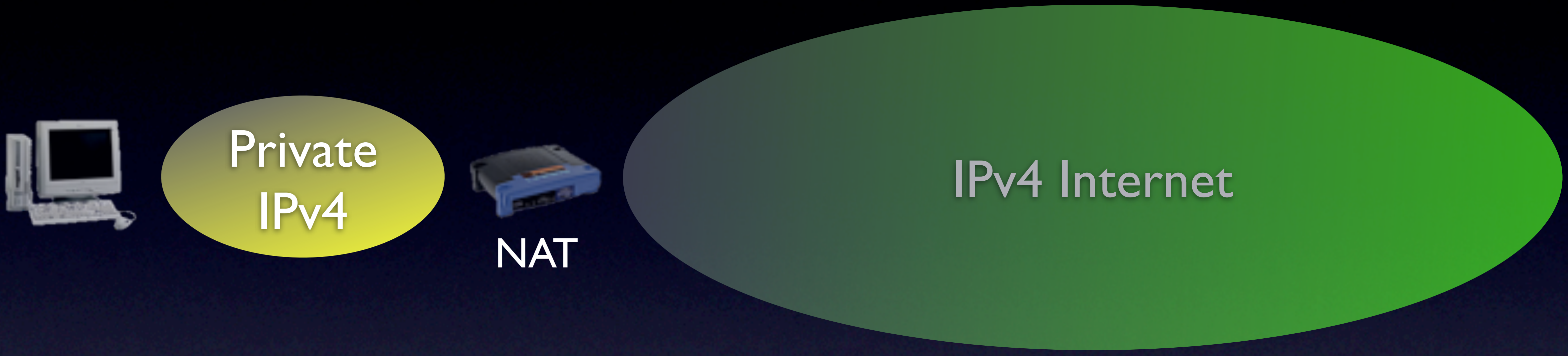
Why Look at Scenarios?

- Focus work on most significant, and most solvable, scenarios
- Solving every possible design iteration is futile

Scenarios

1. IPv4 Sites Reaching Global IPv4 Internet
2. Service Providers Running out of Private IPv4 space
3. “Greenfield” IPv6-only Networks
4. IPv6 Hosts Reaching Private IPv4-Only Servers
5. IPv4 Sites Reaching IPv6-Only Servers

1. IPv4 Sites Reaching Global IPv4 Internet



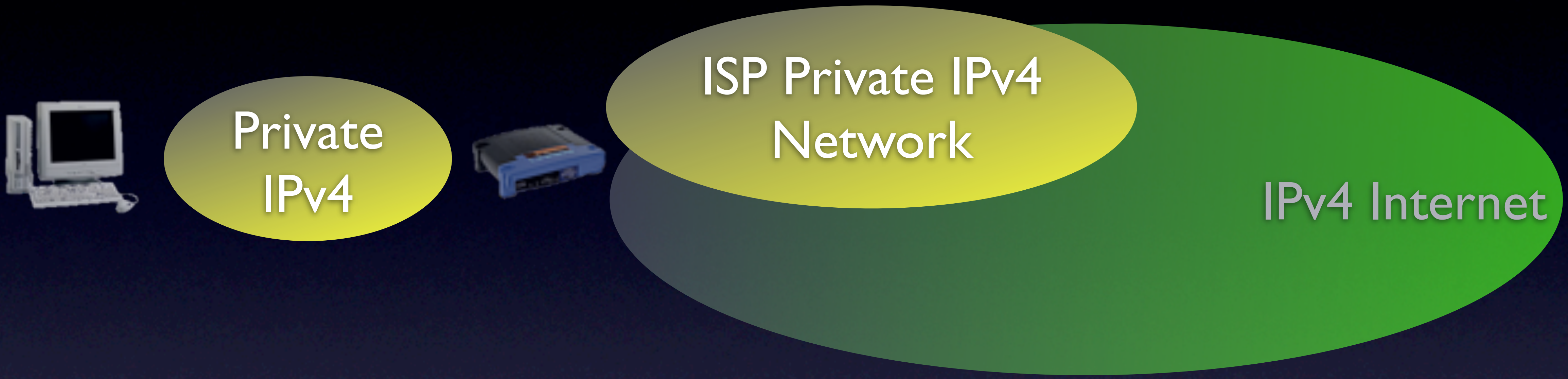
Private IPv4

NAT

IPv4 Internet

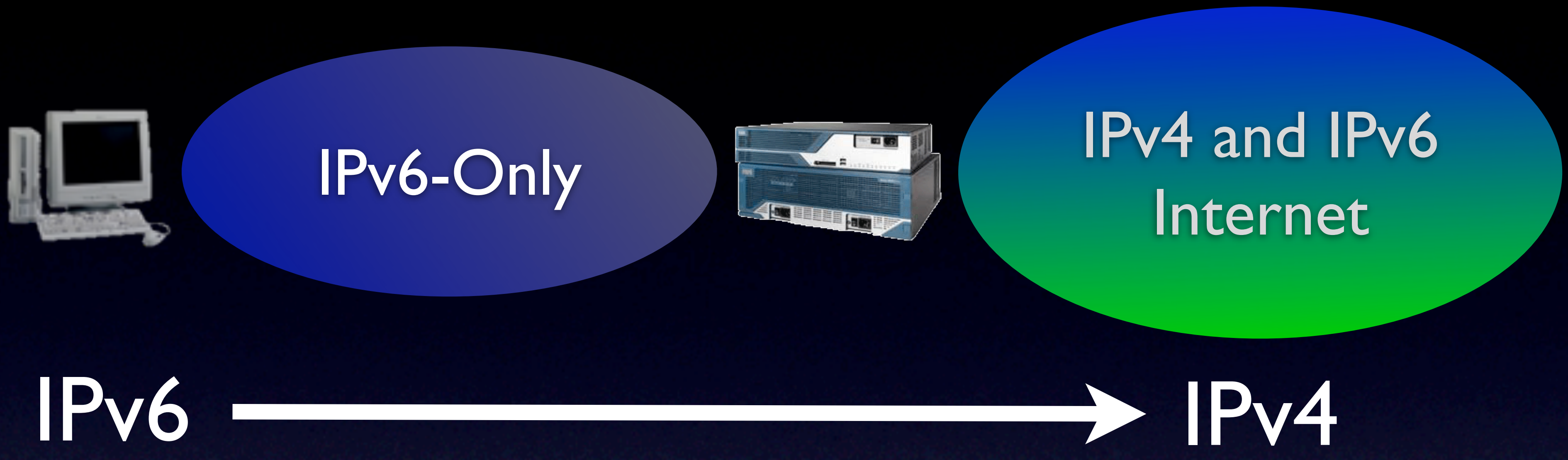
- Keep IPv4 service as unchanged as possible, even without enough addresses
- Single global IPv4 address shared across more than one subscriber

2. Service Providers Running out of Private IPv4 space



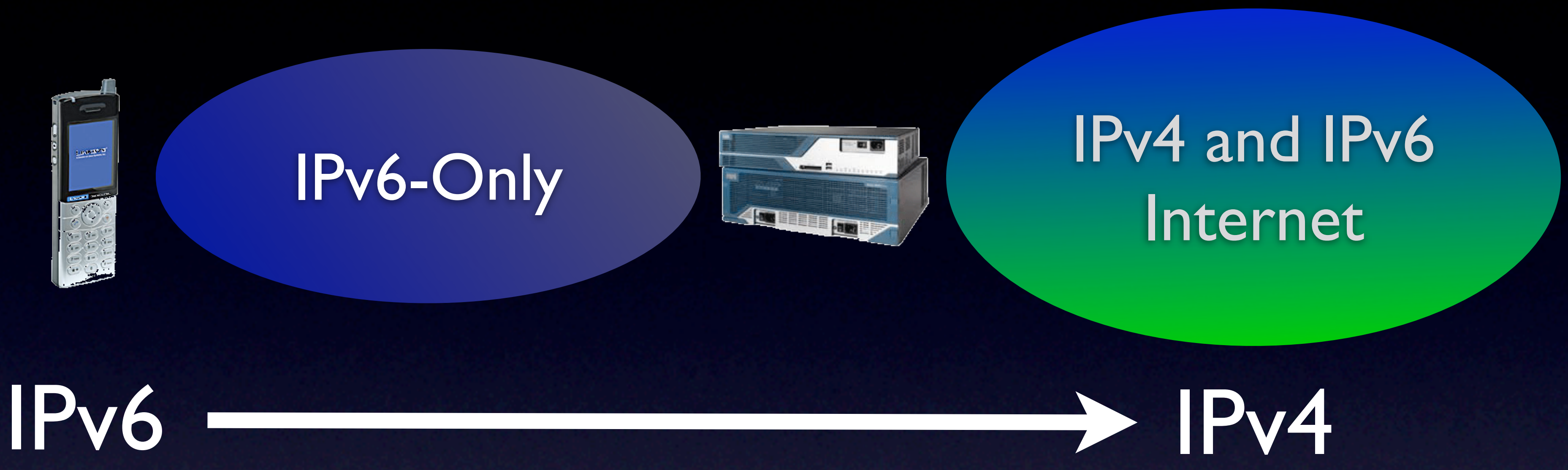
- Service Providers with large, privately addressed, IPv4 networks
- Organic growth plus pressure to free global addresses for customer use contribute to the problem
- The SP Private networks in question generally do not need to reach the Internet at large

3. Enterprise "Greenfield" IPv6-only Networks



- Built from the ground up to run IPv6 only
- Operational overhead of dual-stack considered high
- Ability to specify what equipment is used or not used
- Internal traffic IPv6, but still need to reach IPv4 Internet access

3(a). Wireless “Greenfield” IPv6-only Networks



IPv6-Only

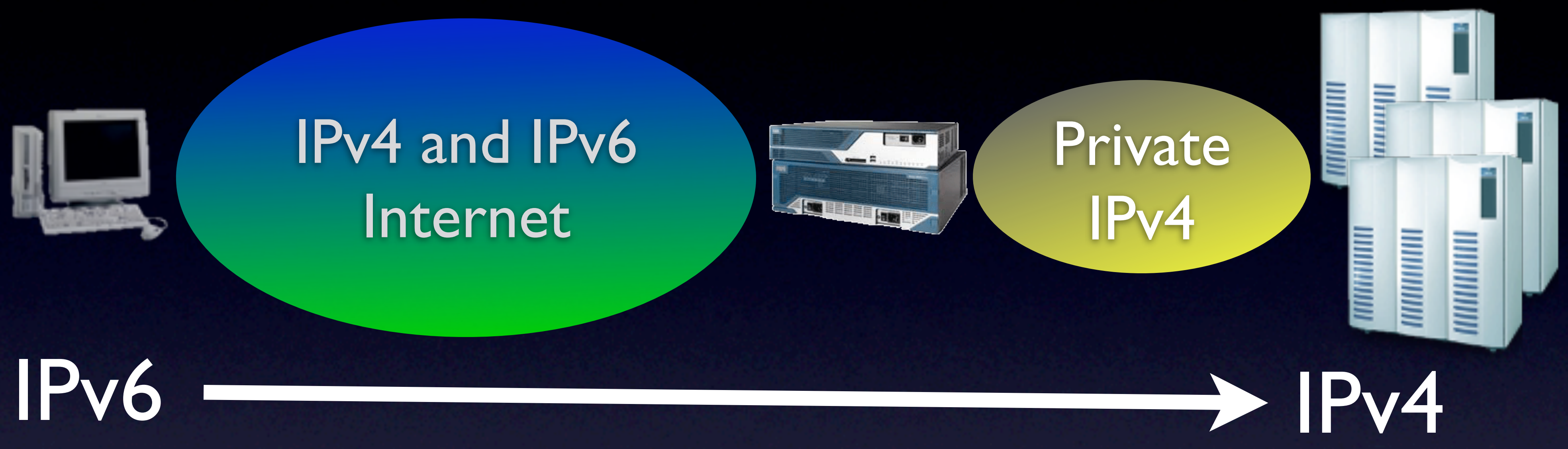
IPv4 and IPv6 Internet

IPv6

IPv4

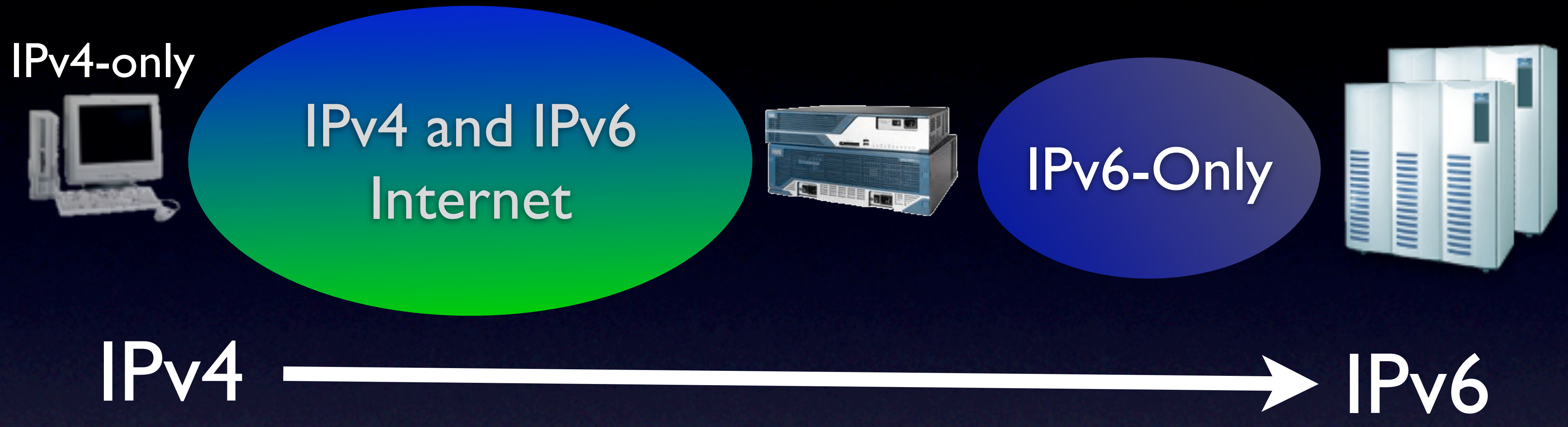
- Topologically similar to Enterprise case
- In Wireless, there may be more control over end-devices than in an Enterprise

4. IPv6 Hosts Reaching Private IPv4-Only Servers



- Multiple servers, running different applications
- Need global reachability, but sufficient if only to hosts that are IPv6 capable (native or via a tunnel over IPv4)
- Similar in function to #3, but with a much smaller target IPv4 network

5. IPv4-Only Hosts Reaching IPv6-Only Servers

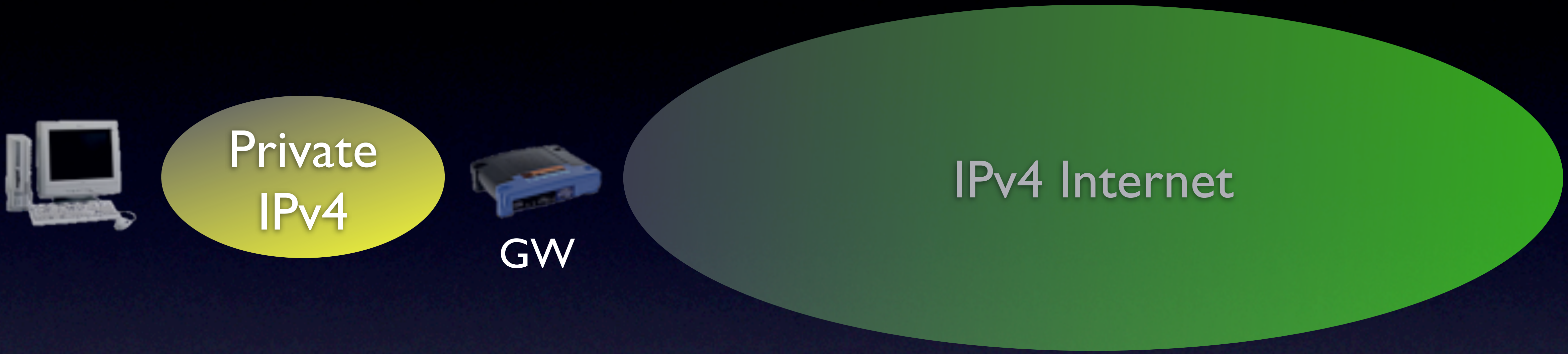


- Exposing IPv6-only servers to the IPv4 Internet
- IPv6 servers share a global IPv4 address for reachability
- Obvious solutions in this space are few (it’s considered “hard”)

Design Space

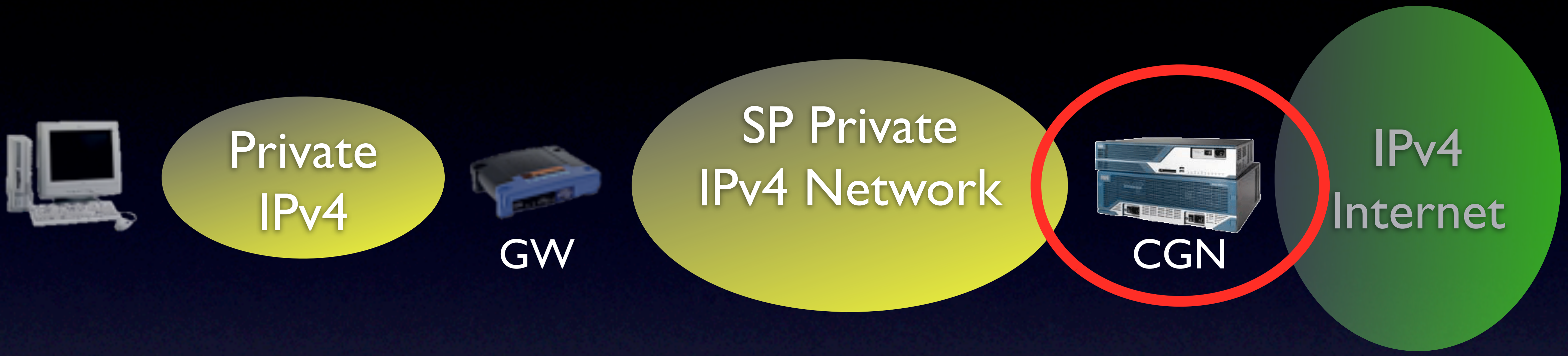
- What: Which elements we introduce or somehow affect
- How: Is new functionality necessary, or can we rely on technology that exists
- When: Changes rolled out in concert or in sequence, sooner or later, etc.

1. IPv4 Sites Reaching Global IPv4 Internet



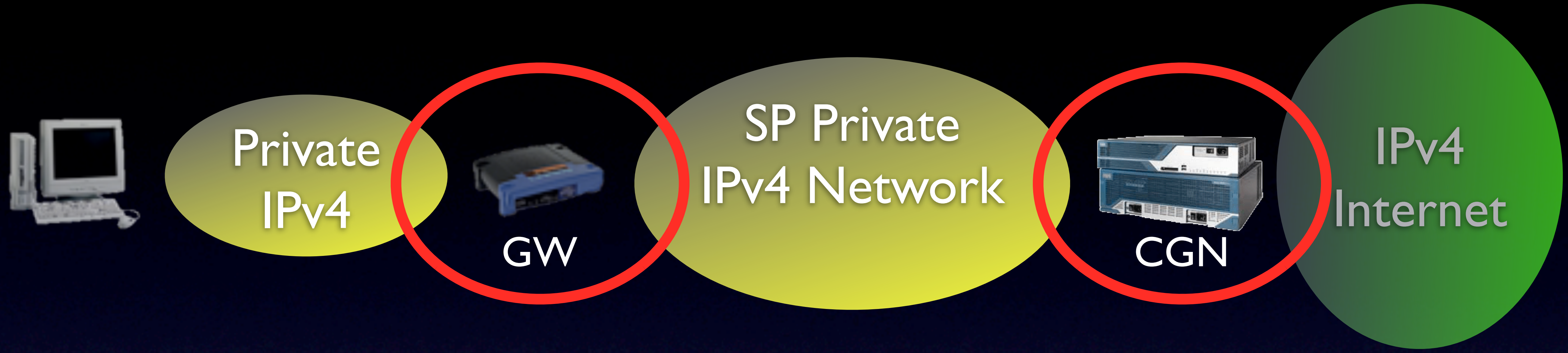
A view of IPv4 Internet Access Today

1. IPv4 Sites Reaching Global IPv4 Internet



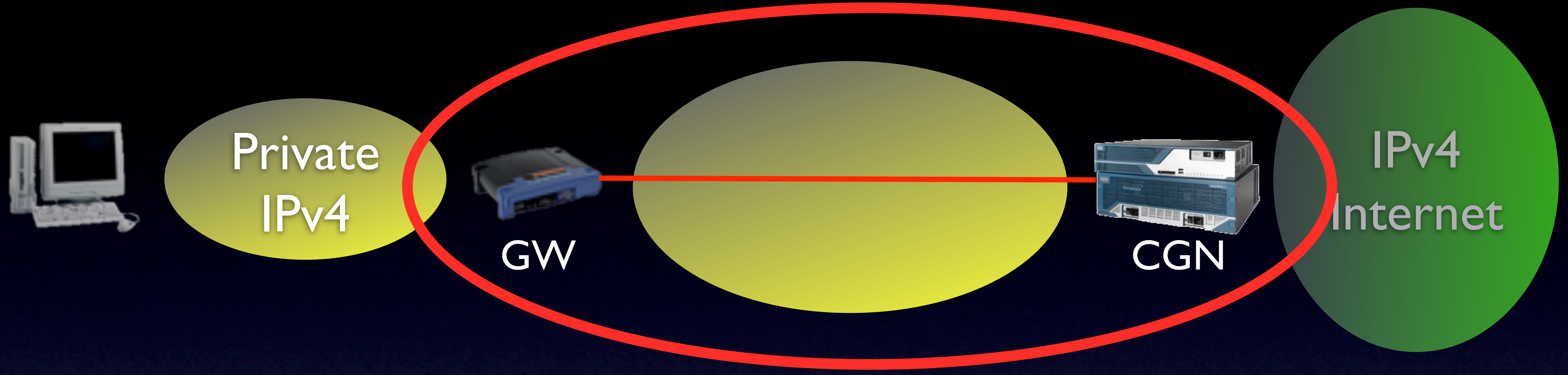
- Fairly obvious approach: More NAT (Carrier Grade!)
- No change to GW, though some GW functionality may be impaired
- Applications are fairly tolerant to NAT, but "Double-NAT" is new territory for some
- All NAT state in GW is duplicated in CGN

1. IPv4 Sites Reaching Global IPv4 Internet



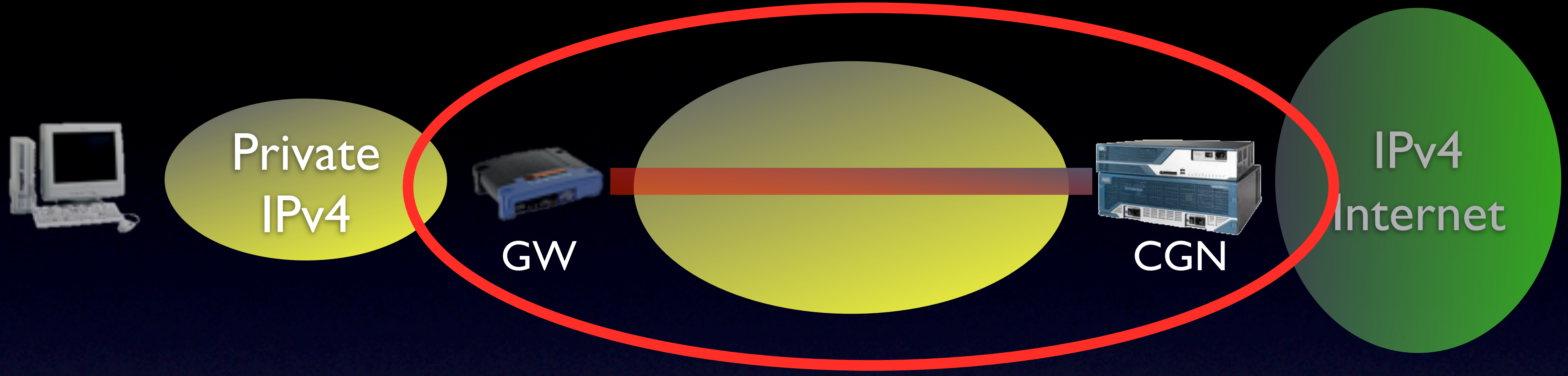
- Don’t like NAT in the GW? Turn it off.
- Delegate a subnet for each site from the SP private address range, and route normally up to the CGN
- Perfect allocation of /29 supports ~2M subscribers
- While this removes the double-NAT, there are certainly operational challenges

1. IPv4 Sites Reaching Global IPv4 Internet



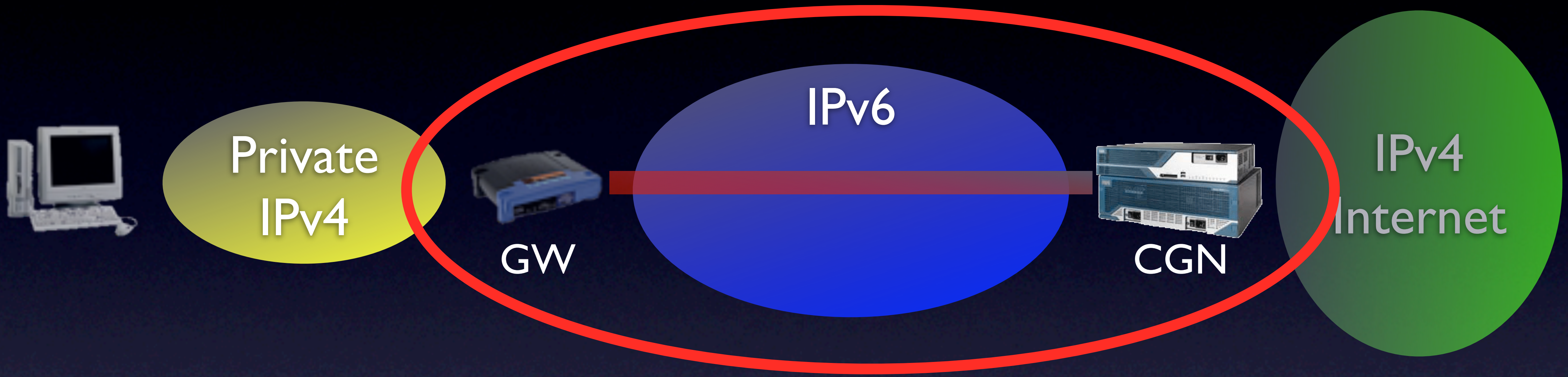
- What if we have point-to-point connectivity between the GW and CGN (common in DSL, FTTH, Cellular, etc)?
- Subscribers can use overlapping address space (including allowing the entire RFC1918 range).
- The GW can route or bridge

1. IPv4 Sites Reaching Global IPv4 Internet



- What if you don't have a point to point link between the GW and CGN?
- Create one with a tunnel

2. Service Providers Running out of Private IPv4 space

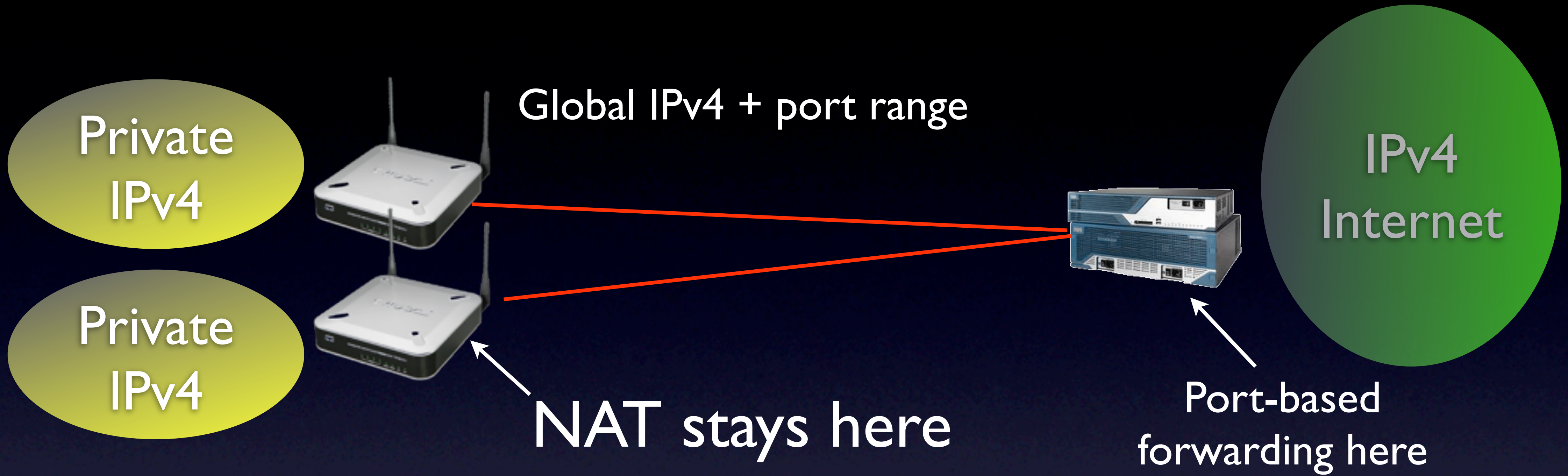


- If we have a tunnel and an IPv6 network to run it over, we can make the tunnel IPv4 over IPv6
- Replace Private IPv4 network with an IPv6 network

- We’ve pieced together tunnels and NATs, but nothing dramatically new so far

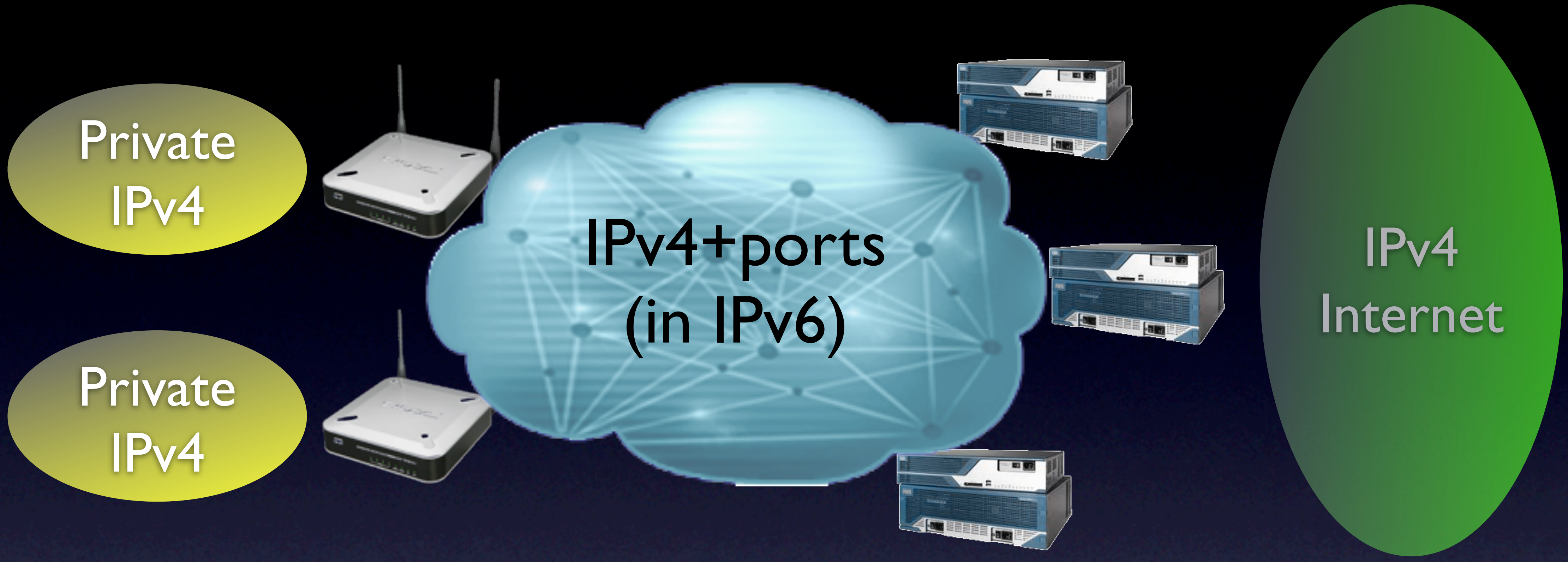
- What if we did specify new functionality and protocols between the GW and “CGN”?

“Fractional addressing” or “Port leasing”



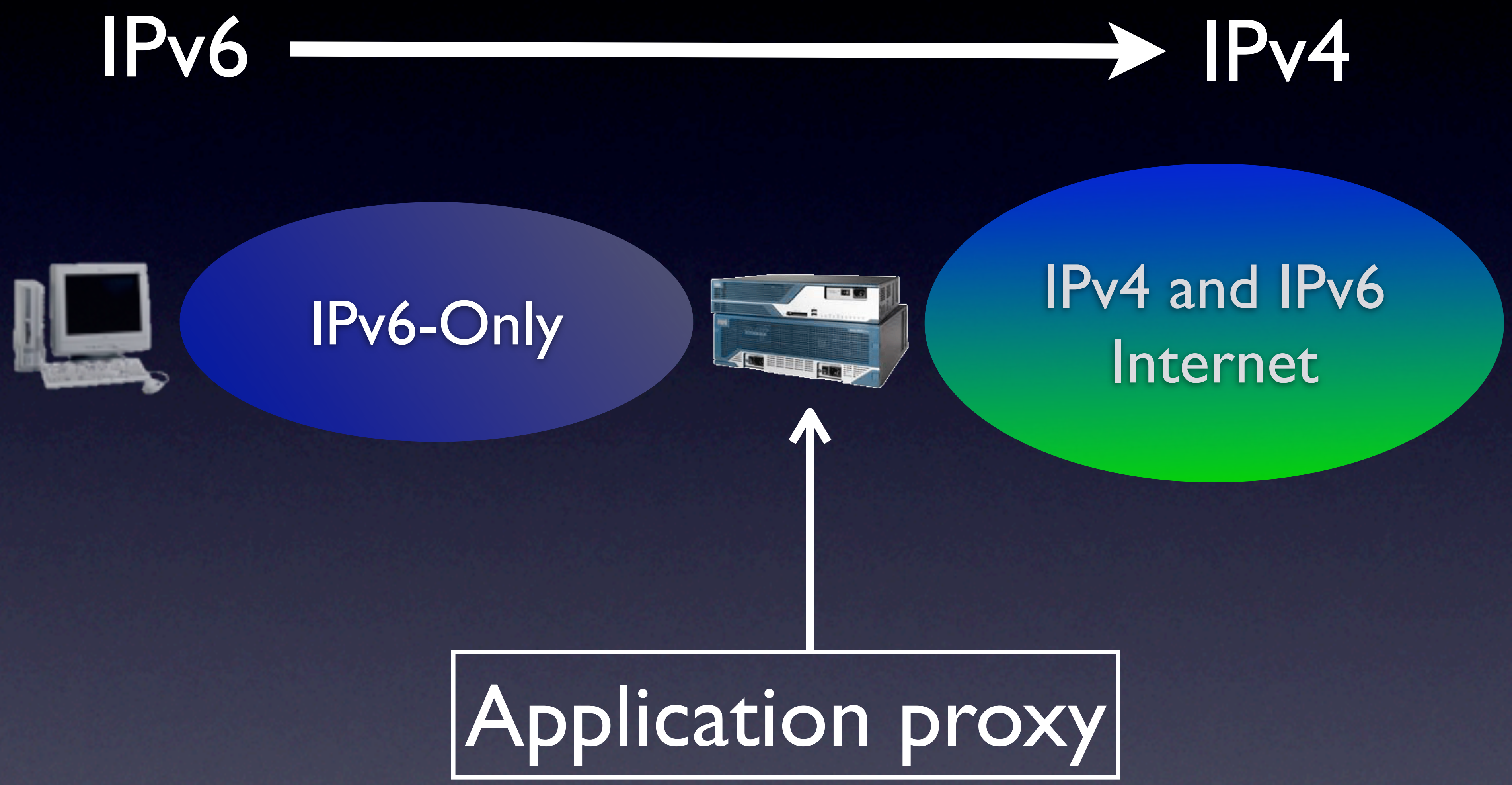
- Fractional addressing remains localized across point to point link
- Applicable to Scenario #1, Scenario #2 if IPv4/IPv6 tunnels are used

“Fractional addressing” or “Port leasing”



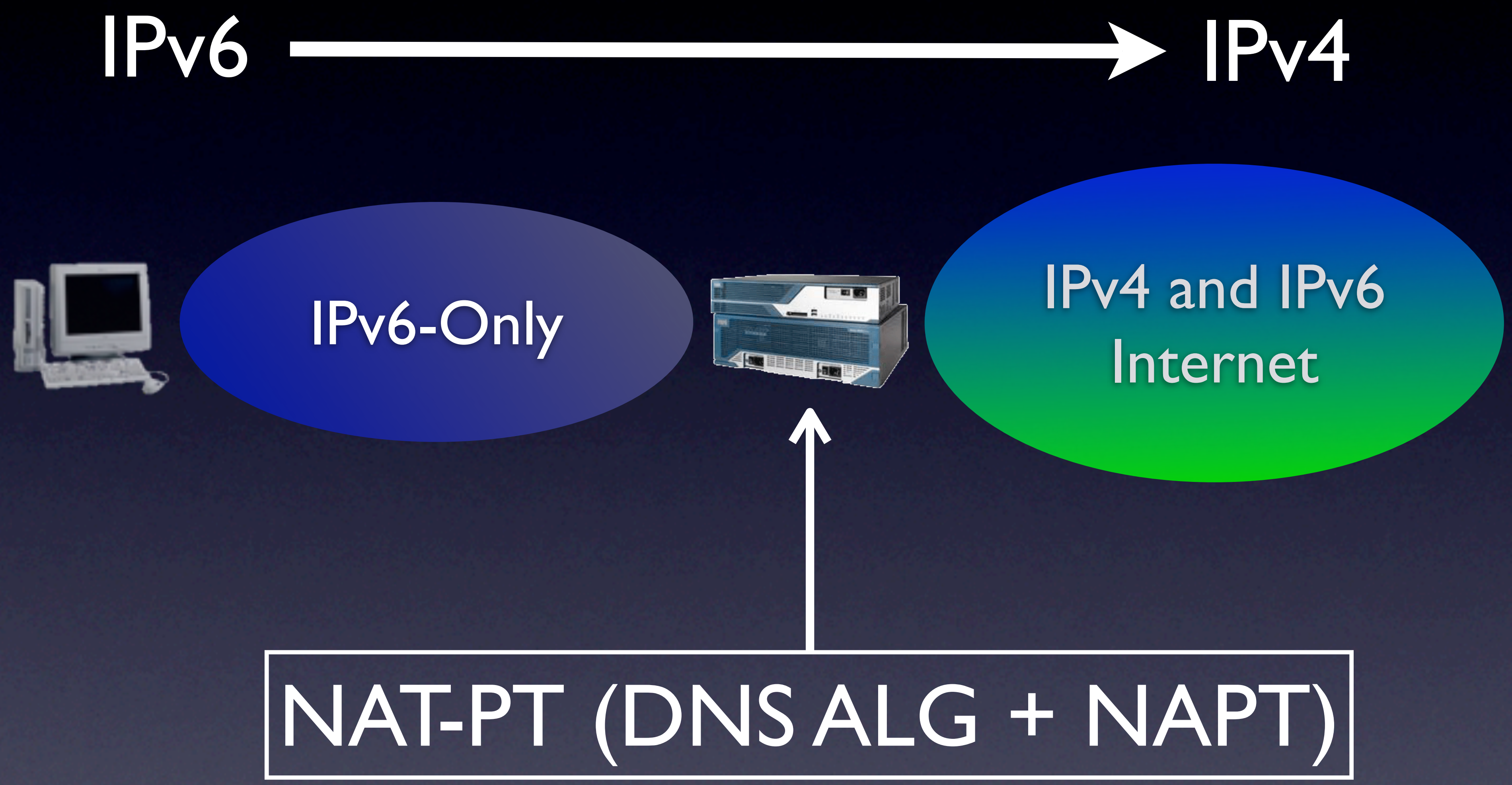
- Point to multipoint connectivity is possible as well
- Port ranges have to be known by all routers, either explicitly (IGP) or implicitly via IPv6 routing (mapping ports into IPv6 space and use of special prefixes)

3. Enterprise "Greenfield" IPv6-only Networks



- Obvious, but limited functionality

3. Enterprise “Greenfield” IPv6-only Networks



IPv6

IPv4

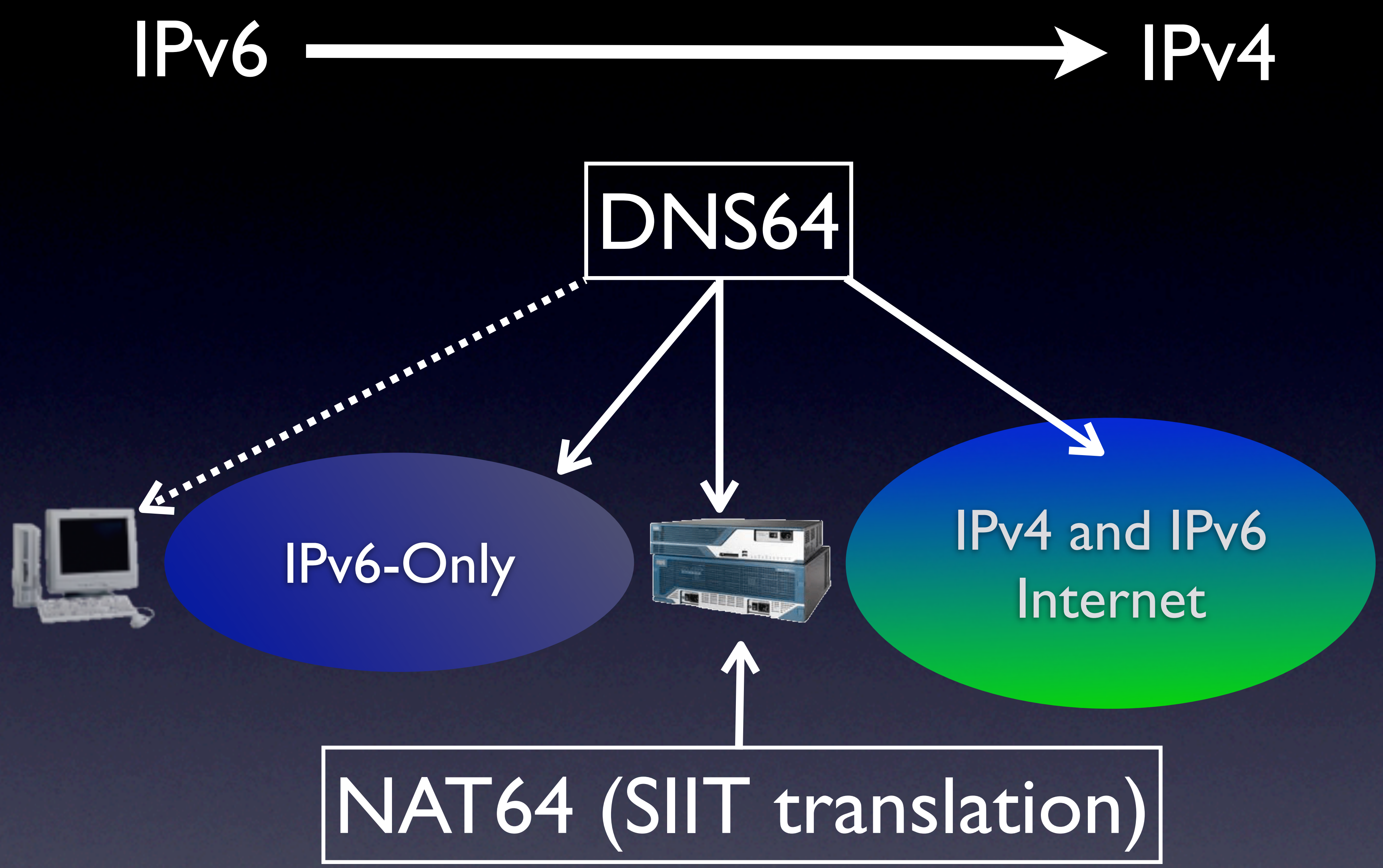
IPv6-Only

IPv4 and IPv6 Internet

NAT-PT (DNS ALG + NAPT)

- More general, exists, but could be improved upon

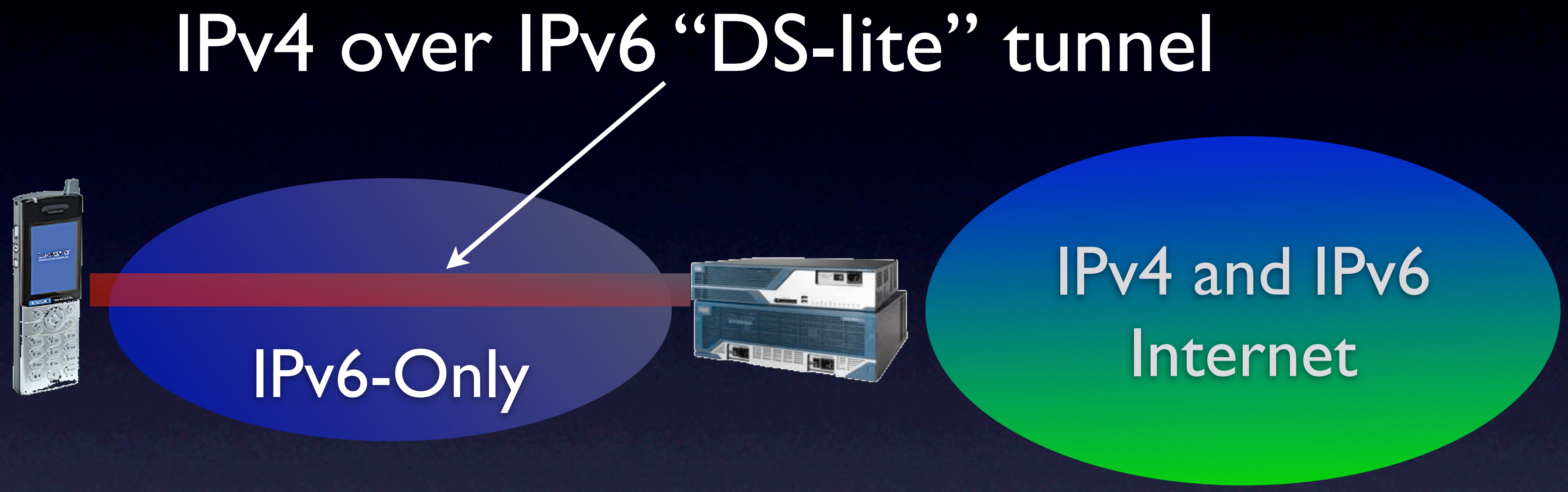
3. Enterprise "Greenfield" IPv6-only Networks



- Where to perform DNS64?
- How to find the translator (Anycast?)
- Challenges with DNSSEC remain

3(a). Wireless "Greenfield" IPv6-only Networks

IPv6 → IPv4



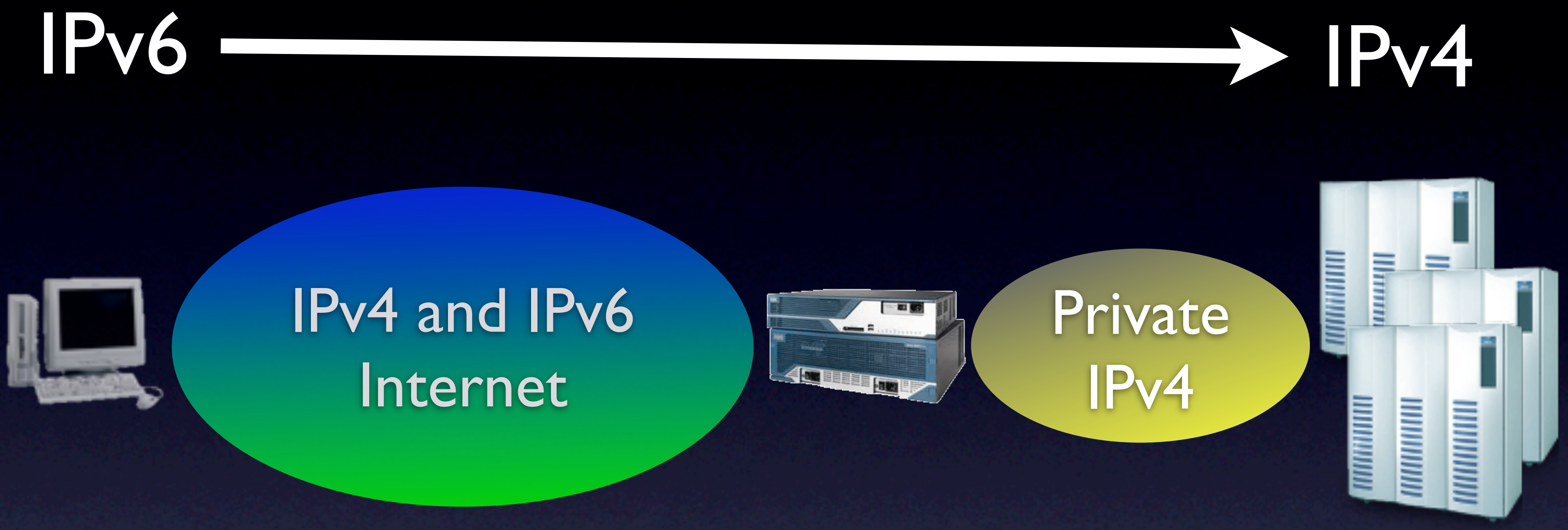
IPv4 over IPv6 "DS-lite" tunnel

IPv6-Only

IPv4 and IPv6 Internet

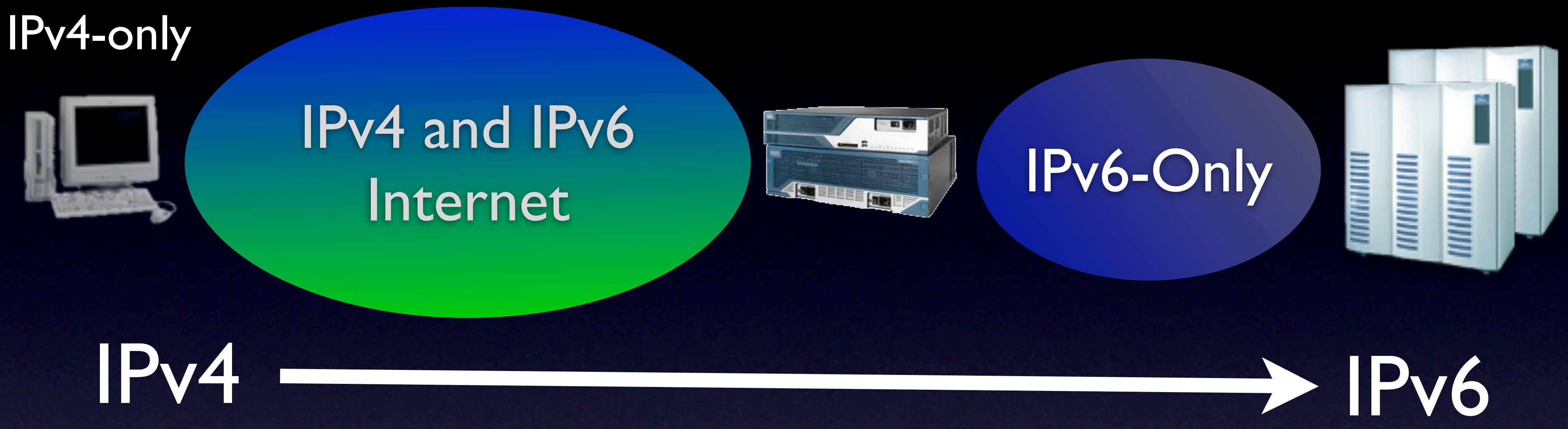
- If we can modify the hosts, "DS-Lite" becomes an option
- Hosts can all have the same IPv4 address - IPv4 operational overhead and address exhaustion problems are still mitigated

4. IPv6 Hosts Reaching Private IPv4-Only Servers



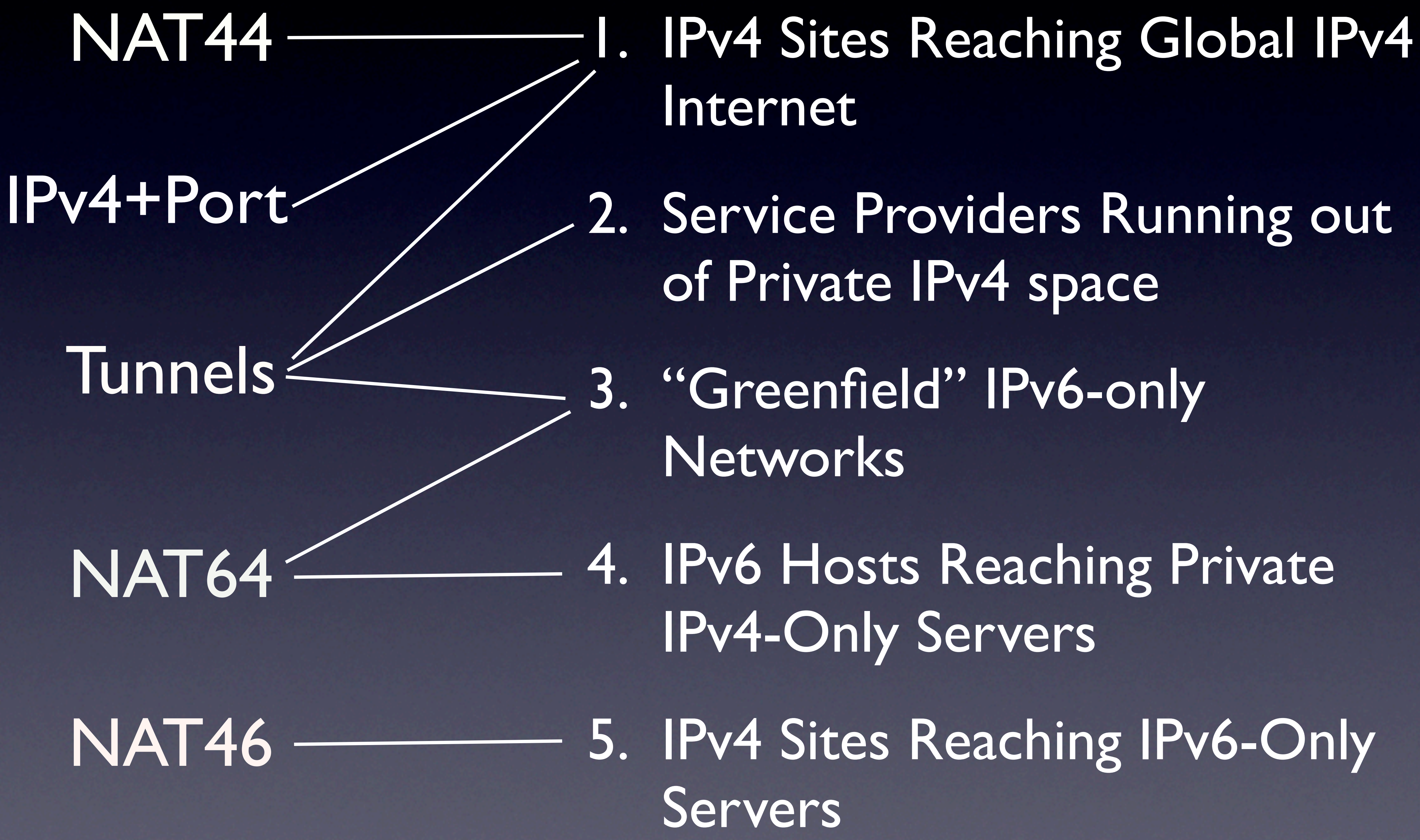
- Same type of translation as #3, but much smaller scale for target network
- Allows for 1:1 IP address translation vs. NAPT
- Deployments using NAT-PT exist, but could be made more resilient (e.g, static vs. dynamic mappings)

5. IPv4-Only Hosts Reaching IPv6-Only Servers



- Certainly not all IPv6 space can be mapped into global IPv4 address space
- NAPT necessary - Requires Port Agility in IPv4 host applications if IPv6 servers need to share common ports (such as port 80)

Scenario Toolkit Mapping



NAT44

IPv4+Port

Tunnels

NAT64

NAT46

1. IPv4 Sites Reaching Global IPv4 Internet
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Questions

- Do we understand the five scenarios presented?
- Are these scenarios important?
- What have we missed? Are there other scenarios that are equally or more important?