Soaring to New Networking Heights

EzIP Enhanced Internet

Presentation to

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- **The IPv4 based Internet went through phenomenal growth during the last few decades.**
- **However, the future is dampened primarily due to the exhaustion of the assignable public address pool.**
- **The challenge is to resolve this issue with minimum perturbation to the deployed equipment and the established operation.**
- **After extensive study, the only solution seemed to be moving on to IPv6. However, IPv6 has not been delivering what was expected.**
- **Apparently, IPv6 is not a superset of IPv4, nor capable of encapsulating the latter. This handicap of not being able to achieve a smooth transition is a major surprise for a protocol that was set out to replace the one being heavily depended upon by everyone in daily use.**
- **Currently, the Dual-Stack approach has to be adopted to allow both to coexist.**
- **A recent review of the IPv4 suggests a fresh possibility for an alternative.**
- **The implication of the Phoenix icon will be apparent after this presentation.**

Outline

A. Why this Proposal

B. What is the Solution

C. Optimum Approach

D. Technical Considerations

E. Enhanced Internet Architecture

F. Summary

- **This presentation will focus on system level concepts and analysis. Afterwards, we can explore related topics of interest.**
- **We will outline the problem parameters, how did we see the light at the end of a very long tunnel by describing an everyday fact that inspired our effort, and then present the proposed approach.**
- **Related technical components are reviewed to substantiate the feasibility and the realizability.**
- **With significant expansion of assignable public IP address as the result of the proposed scheme, not only the IPv4 address shortage has been resolved, but also an even larger reserve pool is created, ready to support additional digital networks. These conditions transcend the current Internet to be a true worldwide communications backbone with improved performances.**

A. Why this proposal

- **IPv4 address pool almost depleted**
- **IPv6 deployment sluggish**
  https://ams-ix.net/technical/statistics/sflow-stats/ether-type
  https://stats.labs.apnic.net/ipv6
- **ISPs in developed regions seeing no incentive to have end-to-end connectivity**
- **Disadvantaged regions concerned with**
  - **being left behind due to technical complexity**
  - **financial burden of going to IPv6**
- **IPv4 and IPv6 coexist on Dual-Stack for quite sometime to come**

- **No quantitative analysis is available about why and how.**
- **Based on up-to-date statistics, IPv6 is carrying only about 2% of the Internet traffic and hardly any country has more than 50% devices ready with IPv6. The former is updated every 15 minutes. The latter is averaged across 7 days.**
- **These seem to correlate with the general impression.**
- **Regardless these aspects, not being able to uniquely identify every terminal is a fundamental handicap for IPv4 to be a full fledged communication protocol.**
- **Currently, the Internet community has settled with the Dual-Stack approach. Under such an environment, we should apply whatever technology that may be appropriate to either.**
- **Today, we will focus on what could be done to improve the IPv4 environment.**

Boundary Conditions

- **Demand - By Year 2020:**
  - **Population: 7.6B (Billion) - World Statistics**
  - **IoT Devices: 50B - Average 6.6 / Person (Assumption)**

  https://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf

- **Supply - IPv4 Address Pool Size: 4B (256 x 256 x 256 x256 from 4 Octets, 8 Bits each)**

- **Address Demand estimated to be 13 times over the supply**

- **Actual usable IPv4 pool much smaller than 4B due to historical allocation practices**

  http://www.iana.org/assignments/ipv4-address-space/ipv4-address-space.xhtml

►

► **To start this analysis, we need to know the quantitative conditions that we are facing with.**

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► **Cisco whitepaper - 2011 April**

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► **The world population has already hit the mark (2017 October).**

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► **The IoT forecast (6.6 IoTs/person) probably is a bit aggressive. However, it is better to have a larger demand number as the target in budgetary planning.**

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► **Basically, the IPv4 address capacity is at best only one 13th of the projected number of worldwide IoTs by Year 2020.**

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► **In reality, the ratio is even worse, because many of the IPv4 addresses have not been properly utilized, as may be seen in the IPv4 Address Space Registry.**

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► **In the past, there have been various techniques proposed to mitigate this issue, without success.**

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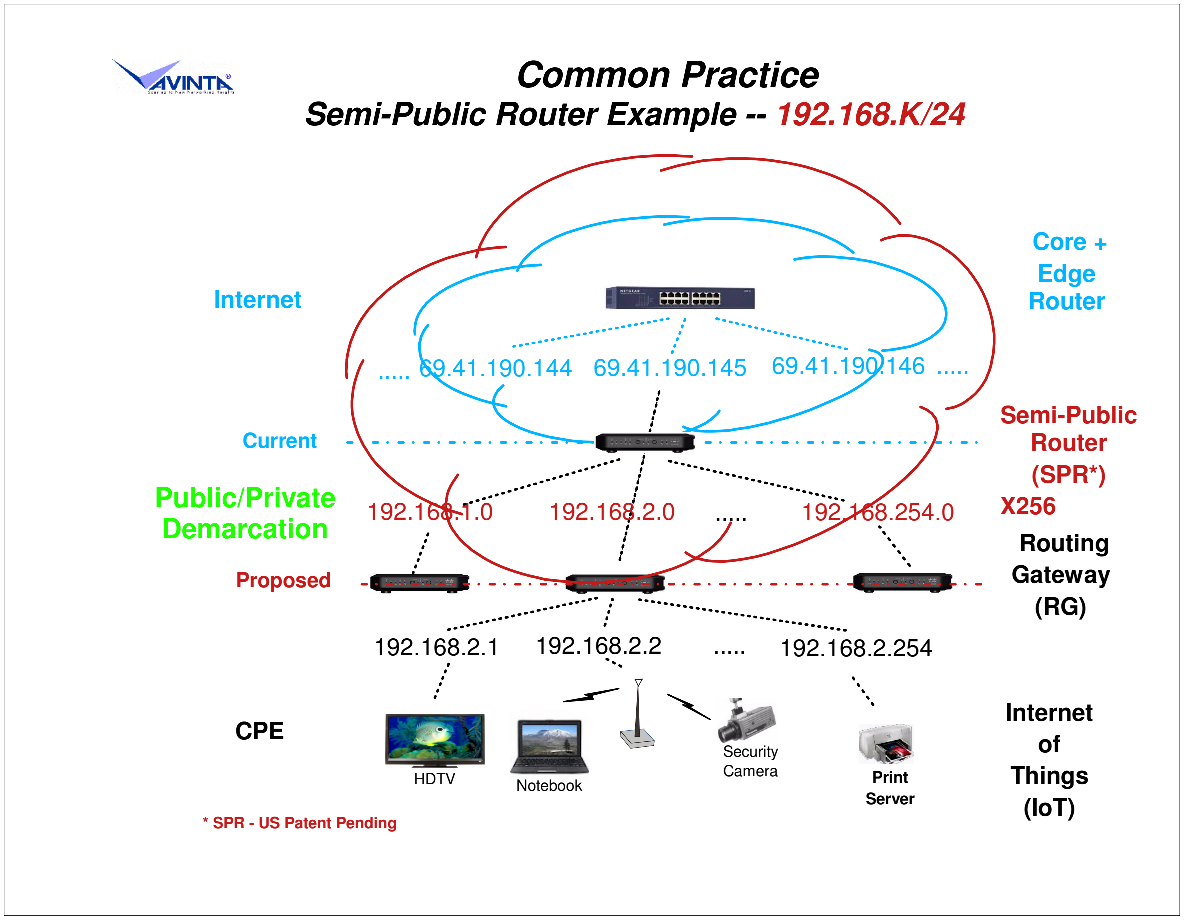
B. What is the solution

- **Expand assignable IPv4 public address pool:**
  - **Introduce Semi-Public Router (SPR) - A simple IPv4 compatible router**
  - **Insert a SPR inline, between an Internet Edge Router (ER) and the private premises it serves, to expand the assignable public addresses**
  - **Designate a block of addresses within the IPv4 pool for SPR to use**

(Refer to example - next slide)

- **Today, we will address the issue directly.**
- **Since SPRs provide public routing functions, the effective assignable IPv4 public address pool is expanded.**
- **To maintain the address format compatibility, a subset of IPv4 addresses need be reserved from the main pool to be used by the SPR operation.**
- ********************
- **The last step may sound contradictory, since the IPv4 pool is officially depleted. However, arithmetically removing a subset of finite number, say 10 elements from a relatively large set, say 4B, has minuscule effect to the overall set. On the other hand, upon applying such a subset geometrically to multiply the remaining set, the effective overall number of elements is expanded accordingly to become 40B (minus 10 x 10 to be exact). As it turns out, a block of address that is much larger than 10 has been identified. This creates a delightfully huge resource.**



- Although everyday Residential Gateways (RGs) are allocated with private network address block 192.168/16, most of RGs are actually operating with the 192.168.K/24 convention, whereby K is a parameter between 0 and 255 preset in the factory. The most common values for the K have been, 0, 1, 2, 10, etc. Under this condition, each private network is restricted to 256 addresses, available from the fourth octet.
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- A group of RGs like the above, each with a different K value, may operate from the same public IPv4 address without conflict. The router that serves these 256 RGs is one of the basic SPRs.
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- Since the RGs have not changed nor moved, the conventional demarcation line remains where it has been from a subscriber's point of view.
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- Applying this configuration to every IPv4 address, we can expand the Internet by 256 times to get the total of about 1000B assignable public addresses that are IPv4 compatible. This is 20 time of the 50B IoTs by Year 2020. Or, even the spare pool is now 19 times of the need.
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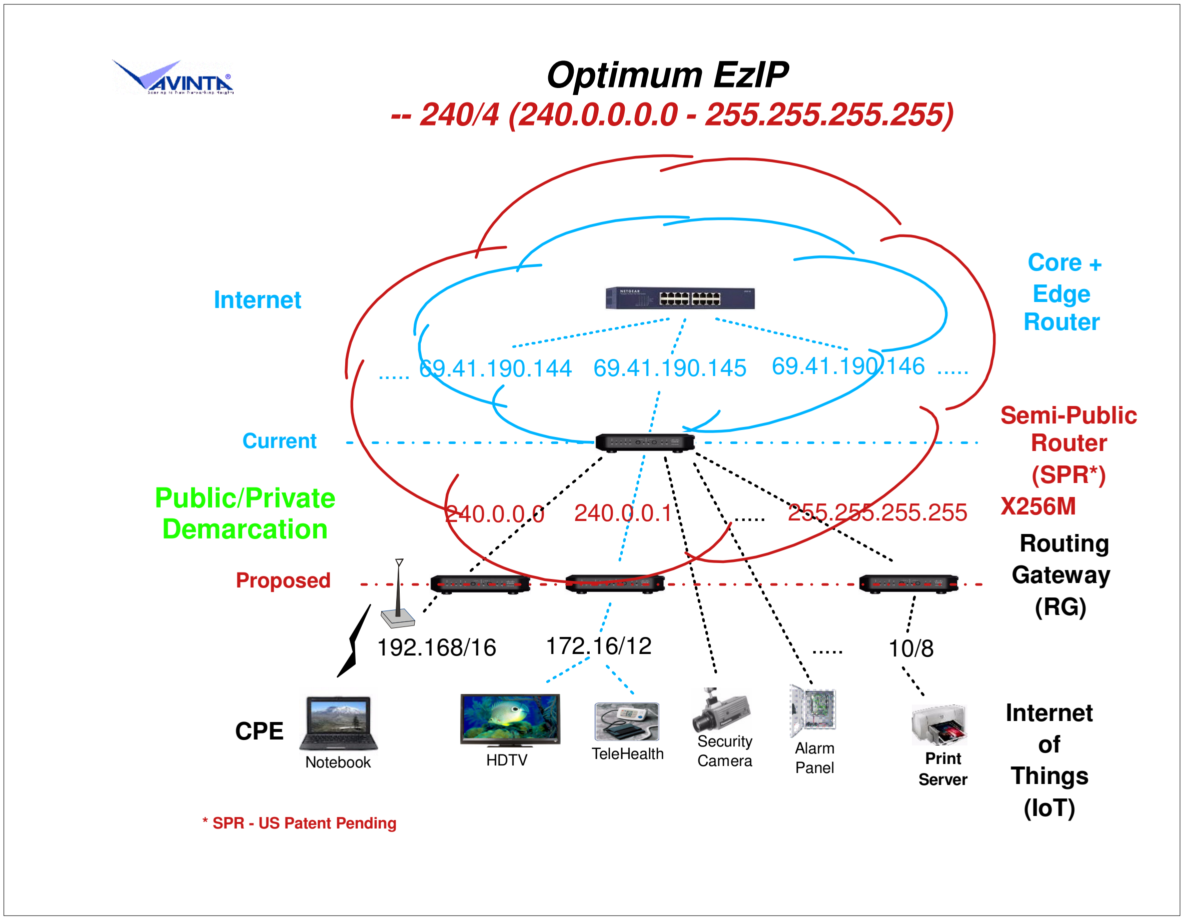
- This finding encouraged us to look further for similar and perhaps better resources. To present these possibilities, we created a name, EzIP (phonetic for Easy IPv4) for referring to various aspects of this effort.

C. Optimum Approach

- **The 240/4 block:**
  - **From 240.0.0.0 through 255.255.255.255 whose first four bits are all "1", totaling 256M addresses**
  - **Reserved for "Future use" since 1981-09: Not routable - neither publicly nor privately**
  - **Offers the potential of multiplying each current IPv4 public address by 256M times, yet**
  - **Does not impact existing public and private networks, nor IoTs**

(Refer to Optimum EzIP example - next slide)

- **The other two private network address blocks, 172.16/12 and 10/8, each can similarly support the SPR to multiply the IPv4 pool by 256 times for a total of 768 times.**
- **However, there are drawbacks with this basic scheme:**
  - **As one octet is allocated for extending the public address, the corresponding private network is reduced accordingly to one 256th.**
  - **By sacrificing all three private networks, the address pool may be multiplied by a factor of over 17M with full end-to-end connectivity.**
  - **Since these address blocks have been used privately without coordination for many years, it will be difficult to reclaim any portion of them, except perhaps the 192.168.K/16 block for EzIP purpose.**
- *****************
- **The better candidate is the 240/4 block (from 240/8 to 255/8). This block has been reserved for a long time and seems to be under utilized at this juncture.**
- **The 240/4 is ideal to be redesignated as address for the SPR to use, without disturbing either of the current two categories of networks, public and private.**



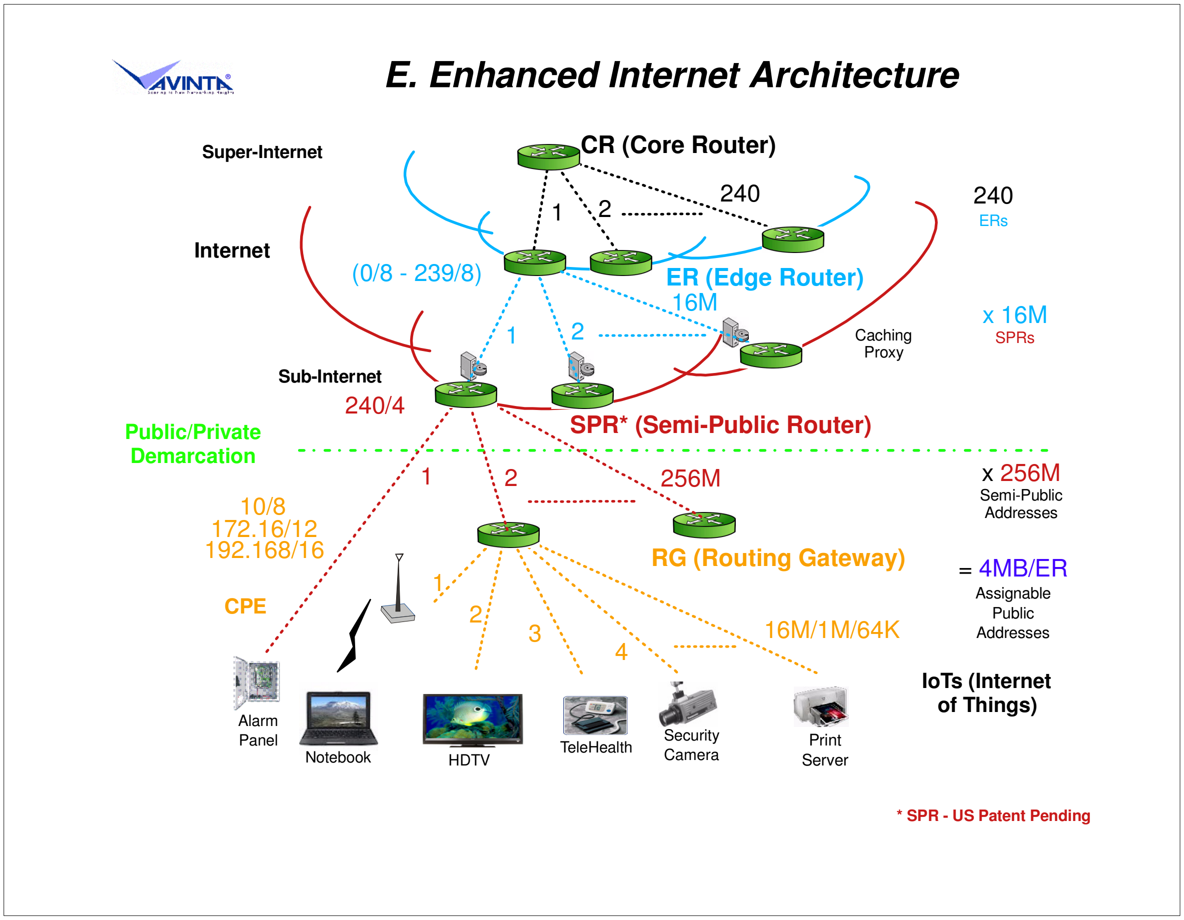
- **Let's start with a basic Internet diagram the same as the previous one, except showing a 172.16/12 private network.**
- **Making use of the 240/4 block, each SPR may expand an IPv4 public address to a publicly assignable pool of 256M addresses.**
- **The Demarcation line will similarly stay where it is currently.**
- **The Internet is now expanded 256M times to have 1000MB IPv4 addresses, or 20M times of the projected IoTs (50B) by Year 2020.**
- **Since 256M (0.256B) addresses have to be reserved from the original IPv4 pool first, the more accurate calculation of the above would be about 0.959BB (3.744B x 0.256B), or 959MB.**
- **To properly implement the EzIP scheme, we need to be sure that the parameters utilized are all available and there is a reliable mechanism to transport such information between SPRs stealthily through the Internet (without disturbing the current setups). This is analogous to the PSTN treating the digitally encoded audio signals between dial-up modems, as if they were part of a voice call.**

D. Technical Considerations

- **APNIC: Requested to redesignate 240/4 for "Private Use" (2. Caveats of Use)**
  https://tools.ietf.org/html/draft-wilson-class-e-02
- **RFC 791: Defined Option mechanism in the IP Header (Figure 9)**
  https://tools.ietf.org/html/rfc791
- **Over a dozen of Option numbers available**
  http://www.iana.org/assignments/ip-parameters/ip-parameters.xhtml
  https://tools.ietf.org/html/rfc6814

(Refer to Enhanced Internet Architecture example - next slide)

- **A Draft by APNIC (2008 - Page 2, Section 2) proposed to use 240/4 as the fourth private network address block, but identified that many deployed private network routers would reject the 240/4 addresses as "experimental".**
- **RFC791 (1981 - Page 38, Figure 9) defined the Option mechanism together with EOOL (End of Operation List) and NOP (No-Operation) Option codes for carrying flexible length information as payload.**
- **One or more Option numbers are needed to identify the 240/4 address information conveyed by the Option word(s) that follows. Out of 32 possible numbers, most have been used. The EzIP application may lead to another resource exhaustion issue. Fortunately, RFC6814 (2012 - Page 4) deprecated nine Option numbers that were assigned to earlier experiments.**
- ***********
- **In brief recap, each SPR can support a region with 39M (256M / 6.6) people that is larger than the most populous city (Tokyo Metro. population: 33M). Consequently, the majority of countries can be served by the EzIP solution with just one IPv4 public address.**
- **This will free up a lot of IPv4 public addresses and opens up the opportunity for systematically planning a fresh and more capable Internet configuration.**



- With the 240/4 block reserved as the extension address pool, we still have 240 blocks (0/8 - 239/8) of addresses for ERs to manage 16M SPRs each. In turn, each SPR handles 256M addresses.
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- Under each ER, the 4MB (16M x 256M) addresses are 80K times of 50B. This is sufficient for every person, on the average, owns over half a million (6.6 x 80K) IoTs.
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- Employing a Caching Proxy as the gateway for an SPR to access its ER will not only improve the data service performance, but also transparently convert between the public IPv4 address used by the ER and the EzIP address used by the SPR. Each SPR can now operate autonomously as a sub-Internet, as well as the backup for one another, even the central databank, in case of failure.
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- Intra-SPR packets which will be the majority traffic may then use the 240/4 addresses directly in the basic IP header, even without the public IPv4 address, much like calls among stations in a PABX (more precise technically, a CENTREX - "CENTRal office EXchange") using only extension numbers without prefixing the PSTN number.
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- After using the first ER to host the entire current Internet, the remaining 239 ERs are ready to support additional similar-sized networks. The immediate candidate may be the satellite based Internet being discussed. This proposed architecture essentially transcends the current Internet fabric (CR & ER) to become the backbone for multiple worldwide communication systems, normally operating at arm's length to one another.

F. Summary

- **Address Expansion**
  Multiply each IPv4 address by 256M fold
- **Deployment Configuration**
  Autonomous Sub-Internets
- **Operation Discipline**
  Inherent GeoLocation Property
- **Enhanced Architecture**
  CR with ERs as Super-Internet Backbone
- **Growth Ready**
  239 new worldwide Internet-sized networks

- **Address Expansion: Each IPv4 public address may now serve a stand-alone area with population up to 39M. This is larger than the largest city, Tokyo Metro: 33M. Thus, most countries require only one public addresses to serve all needs.**
- **Deployment Configuration: Making use of the Caching Proxy technology as the gateway building block, each SPR service area becomes an autonomous sub-Internet, with most traffic confined within. Thus, standard IP header may use just the 240/4 address for routing, no need to invoke the EzIP header format.**
- **Operation Discipline: Instead of being private properties owned by ISPs, regard IP address as public resource. So that its administration can mimic the PSTN conventions for telephone numbers, mitigating the root-cause of CyberSecurity vulnerability.**
- **Enhanced Architecture: The combination of the CR and 240 ERs may be viewed as the fabric for a Super-Internet. Each ER manages one /8 block of IPv4 addresses. Each such address terminates in an SPR. The first ER will be used for the current Internet, with 80K times of spare capacity.**
- **Growth Ready: The remaining 239 ERs are ready to support new worldwide Internet-sized digital communication systems, normally working at arms-length to one another, yet fully interoperable through the same IPv4 protocol.**