A Deterministic Internet

Presentation to

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2025 June __

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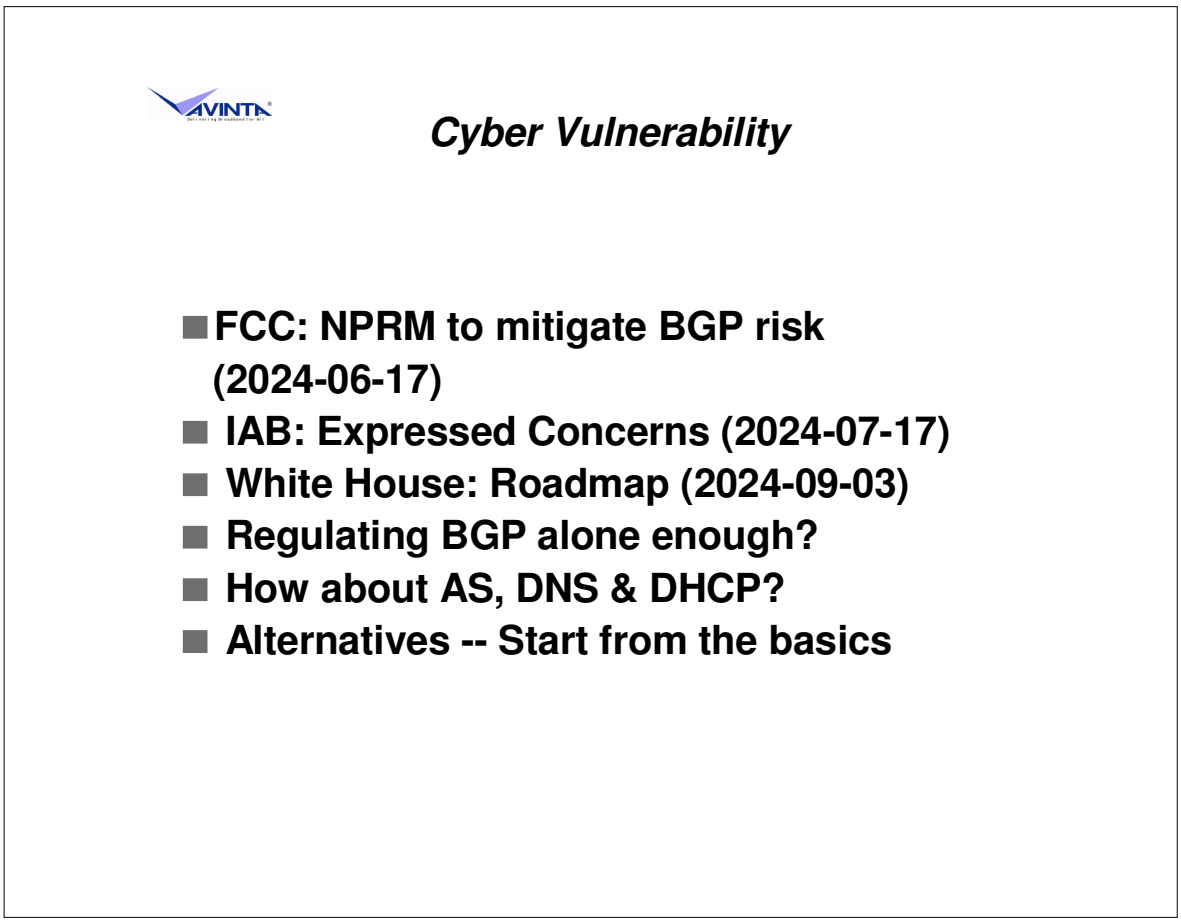
- Although the Internet achieved phenomenal advances during the last few decades, it is full of ***confusions, contradictions, or even convolutions***, depending on one's perspective. For example,
- The Internet promotes ***leveling the playing field*** for everyone. But, ***US gets 4.91 IPv4 addresses per capita,*** while ***Zambia gets only 0.01***. The ratio is nearly 500:1, or ***2.6 orders of magnitude*** apart. ***Over a dozen entities get no allocation, while Vatican City gets 21.4.*** - This is far from equity.
- The Internet promised **end-to-end connectivity**. But, its current predominate operation model, ***Content Delivery Network (CDN)*** based on a ***master-slave architecture*** impedes such, ***even within a local community.*** This is a far-cry from the ***PSTN with IDDD*** (International Direct Distance Dialing) service.
- The Internet took issue with ***telco monopoly and government regulation on PSTN***. Yet, we now have ***multinational conglomerates*** that each **dominates** a respective business sector to the point of ***ignoring responsibilities and evading regulations.***
- Also, the potential of roughly ***195 nations fragmenting*** the Internet to a ***geopolitical Splinternet*** is being criticized while the ***ASes*** have already created a ***76K layer Onion-net***.
- The most puzzling fact is that the Internet vigorously defends its ***border***less policy while the current routing is based on BGP (***Border*** Gateway Protocol).
- Overall, the Internet is ***vulnerable to security breaches***, ranging from harassment to ransomware.
- Today's talk, "***A Deterministic Internet***" is the result of a study program, called ***EzIP (***phonetic for ***Easy IPv4)*** that is part of Avinta's ***Project Phoenix***.



►We will begin with a quick look at the ***latest US Government attempting to manage the BGP*** for cyber security.

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■ ***FCC NPRM: "Reporting on Border Gateway Protocol Risk Mitigation Progress"***

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► https://www.federalregister.gov/documents/2024/06/17/2024-13048/reporting-on-border-gateway-protocol-risk-mitigation-progress-secure-internet-routing

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■ It received concerns expressed by Internet organizations headed by ***IAB***:

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►***"Comments of the Internet Society, by Internet Architecture Board, and Internet Corporation for Assigned Names and Numbers*** in the Matter of "Reporting on Border Gateway Protocol Risk Mitigation Progress"

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► https://datatracker.ietf.org/doc/statement-iab-comments-of-the-internet-society-internet-architecture-board-and-internet-corporation-for-assigned-names-and-numbers-in-the-matter-of-reporting-on-border-gateway-protocol-risk-mitigation-progress/00/pdf/

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■ Finally, ***White House*** issued a Roadmap document to regulate BGP (Border Gateway Protocol) approaches and options for addressing Internet security challenges:

►

►***"Roadmap to Enhancing Internet Routing Security"*** A Report by the White House Office of the National Cyber Director September 2024

►

► https://bidenwhitehouse.archives.gov/wp-content/uploads/2024/09/Roadmap-to-Enhancing-Internet-Routing-Security.pdf

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■Is there a more fundamental approach to the cyber security issue? A revisit of the overall environment suggests that there might be a fresh alternative.

Outline

A. Resources Hidden in Plain Sight
B. Simple Activation
C. Utilize Existing Architecture
D. Tethering Private Network
E. Paralleling Overlay Network
F. Use Cases
G. Summary

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►With limited time, this presentation will focus on ***general concepts and system analyses***. This allows us to see the whole picture first. The cited references will provide the details.
►
►(Like the common wisdom of seeing a forest from an ***airplane at 35K ft up in the sky***. Today, we will do so from even farther away, perhaps more like ***10K miles away in the space***.)
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■**A. .....**
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■**B.** ***No new technology to develop.*****.**
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►
■**C.** ***Only deployment effort.***
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■**D.** An ***US domestic example*** provides the concept of the scheme.
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■**E.** A ***global view*** of the general deployment.
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■**F. Two potential current use cases.**
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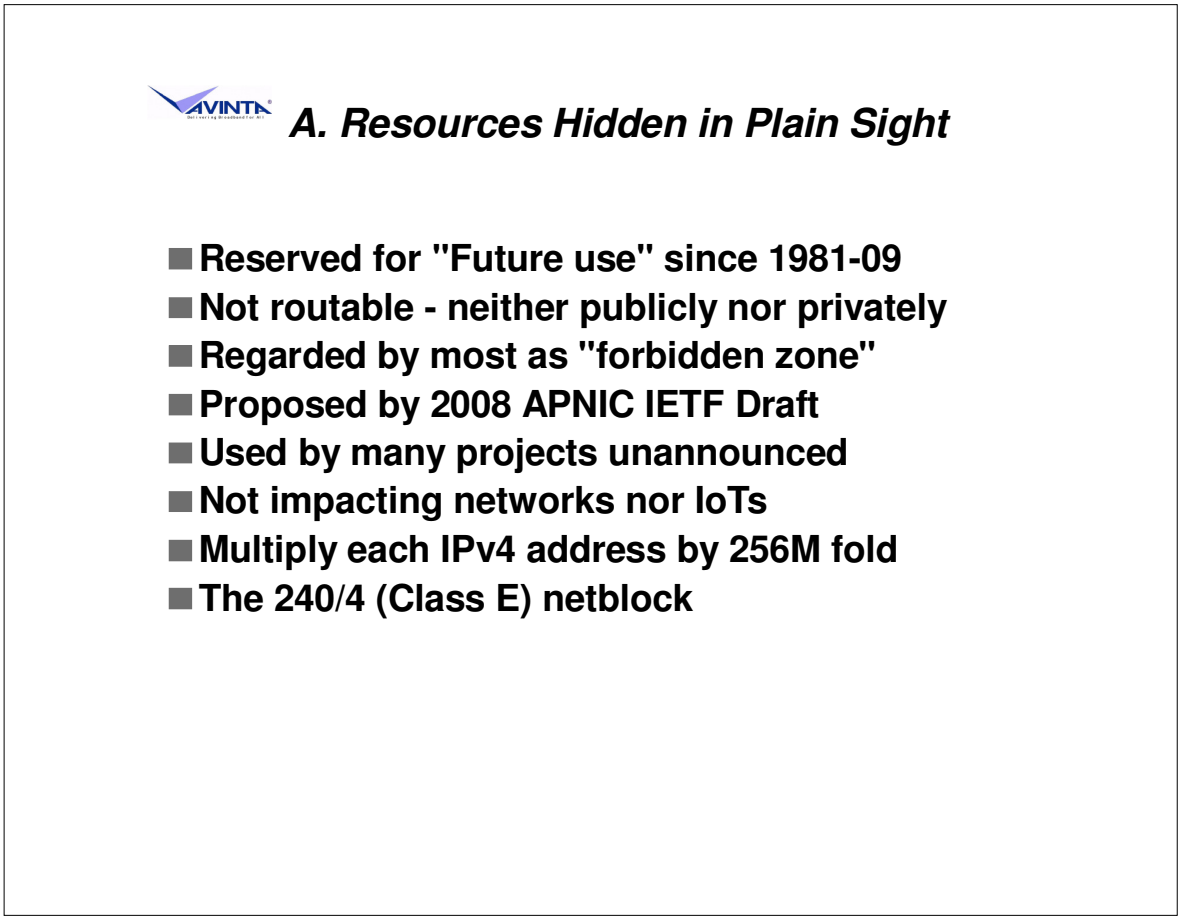

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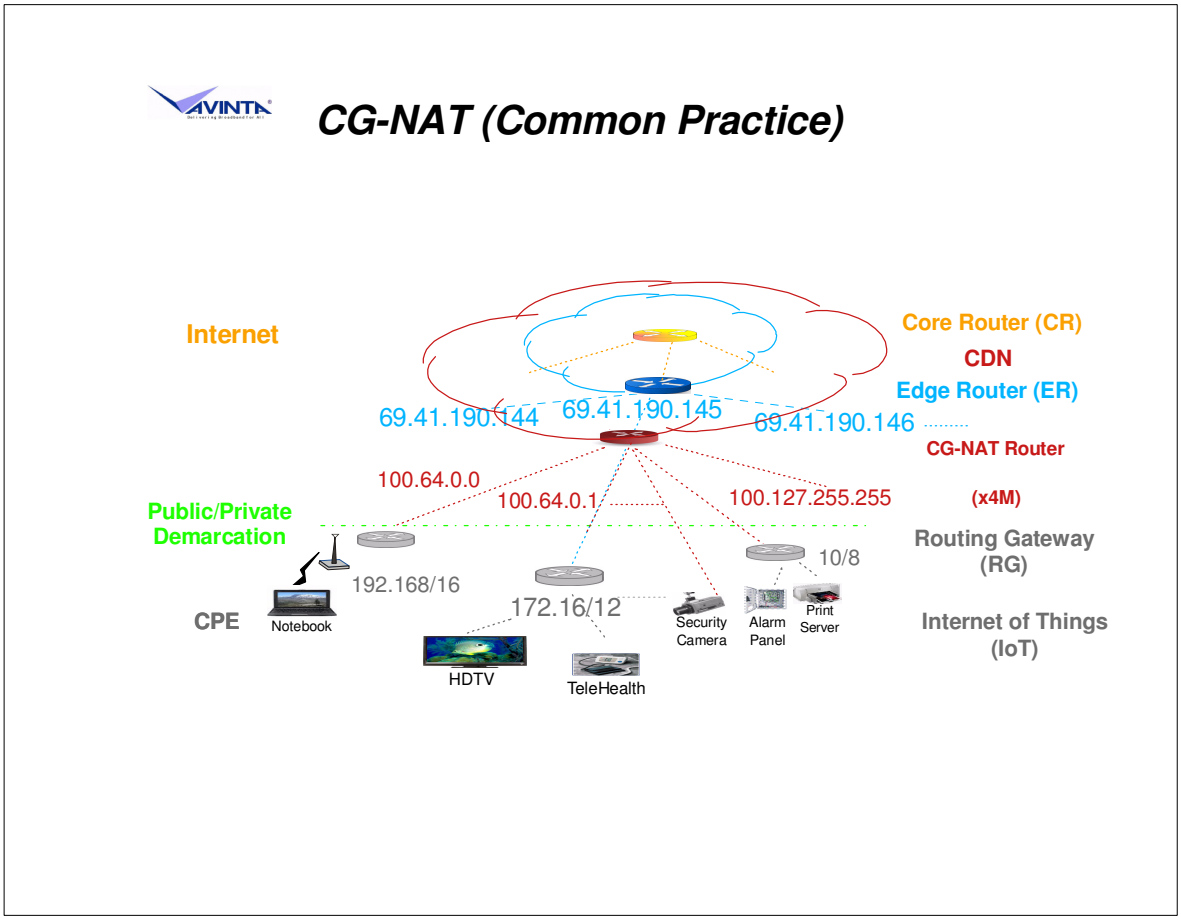
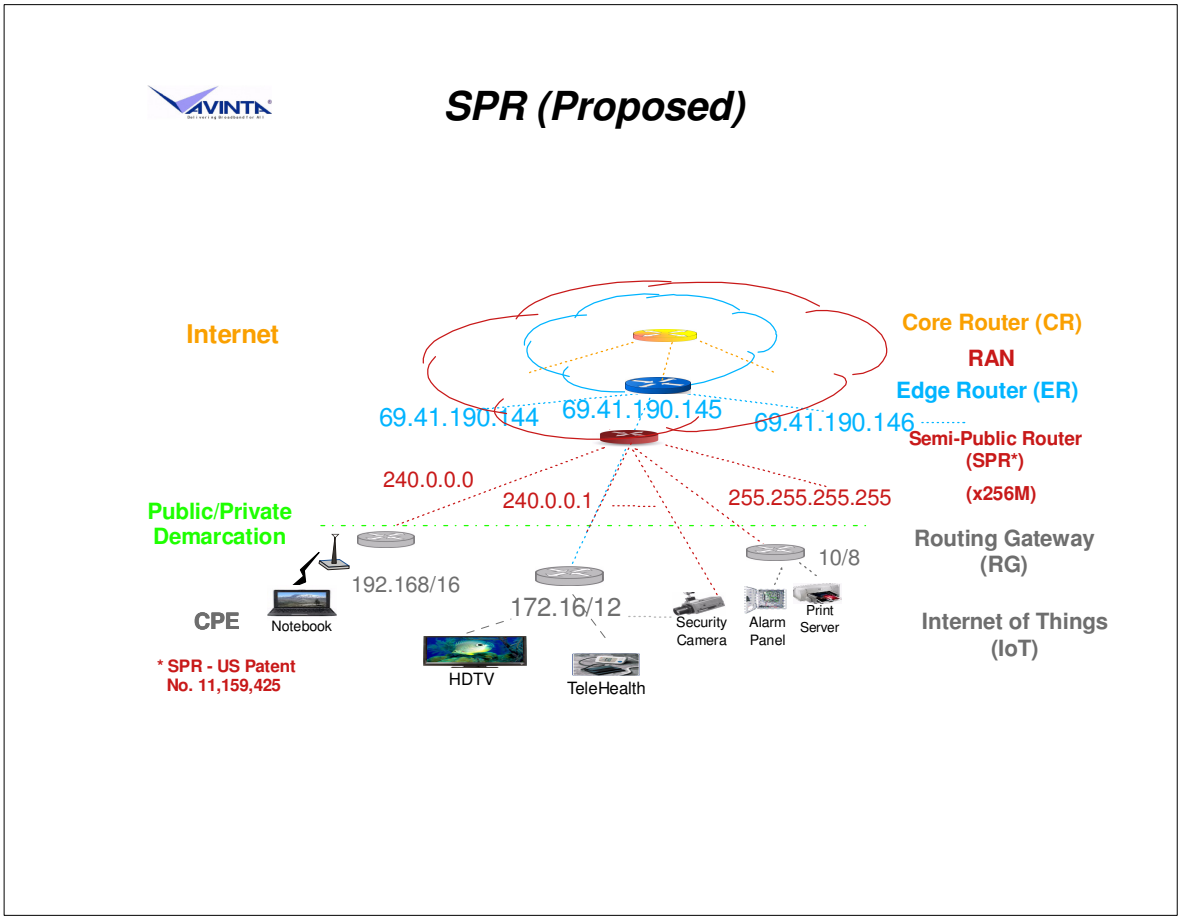
- **.....**
- Proposed to ***private use*** which already had too many IoTs to change.
- In a sense, the uncoordinated uses through the years are fragmenting the Internet.
- The alternative interpretation of these is ***no need to get IETF approval***.
- **.....**
- **Related netblock sizes:**
- **RFC1918 - Private:**
  - **10/8: 16M**
  - **172.16/12: 1M**
  - **192.168/16: 64K**
- **Total: 17.064M**
- **RFC6598 - CG-NAT:**
  - **100.64/10: 4M**



- Let's start with a couple graphic diagrams to get a ***general visual*** of what we are talking about.
- This is the basic Internet configuration: ***CR (Core Router) -> ER (Edge Router) -> RG (Routing / Residential Gateway) -> IoTs (Internet of Things)***.
- Inserting a ***CG-NAT router (using RFC6598 100.64/10 netblock)*** between ER and RG, each public IPv4 address can be ***expanded by 4M fold.***
- Deploying CG-NAT around the globe, the current predominate Internet architecture, ***CDN (Content Delivery Network)*** is formed.
- Within each isolated CG-NAT cluster with ***fewer than 4M subscribers, peer communication*** is possible.
- Attempting to serve more population within ***each CG-NAT cluster,*** by ***dynamic reuse*** of 100.64/10 netblock, however, ***defeats the peer communications*** goal.



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- ■ Let's start from the basic Internet again.
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- ■ By applying 240/4 to CG-NAT routers, ***SPRs*** are formed with ***each having 256M address*** capacity.
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- ►
- ■ Deploying ***SPR all around the world, a new layer of routers forms RAN (Regional Area Network).***
- ►
- ►
- ■ This ***64 fold addressing capability increase*** is significant. For example, if each person is assigned with one 240/4 address, ***only 4 countries (India, China, US ad Indonesia)*** in the world have population exceeding the capability of one RAN.
- ►
- ► If RANs focus on serving premises, using US statistics of ***three residents per household, only India and China have more premises than the capacity of one RAN.***
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- ►
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- ■ Note that these numbers are ***ball park estimate***s for orienting our minds about the ***order of magnitude of a practical IP address pool*** may be***.***
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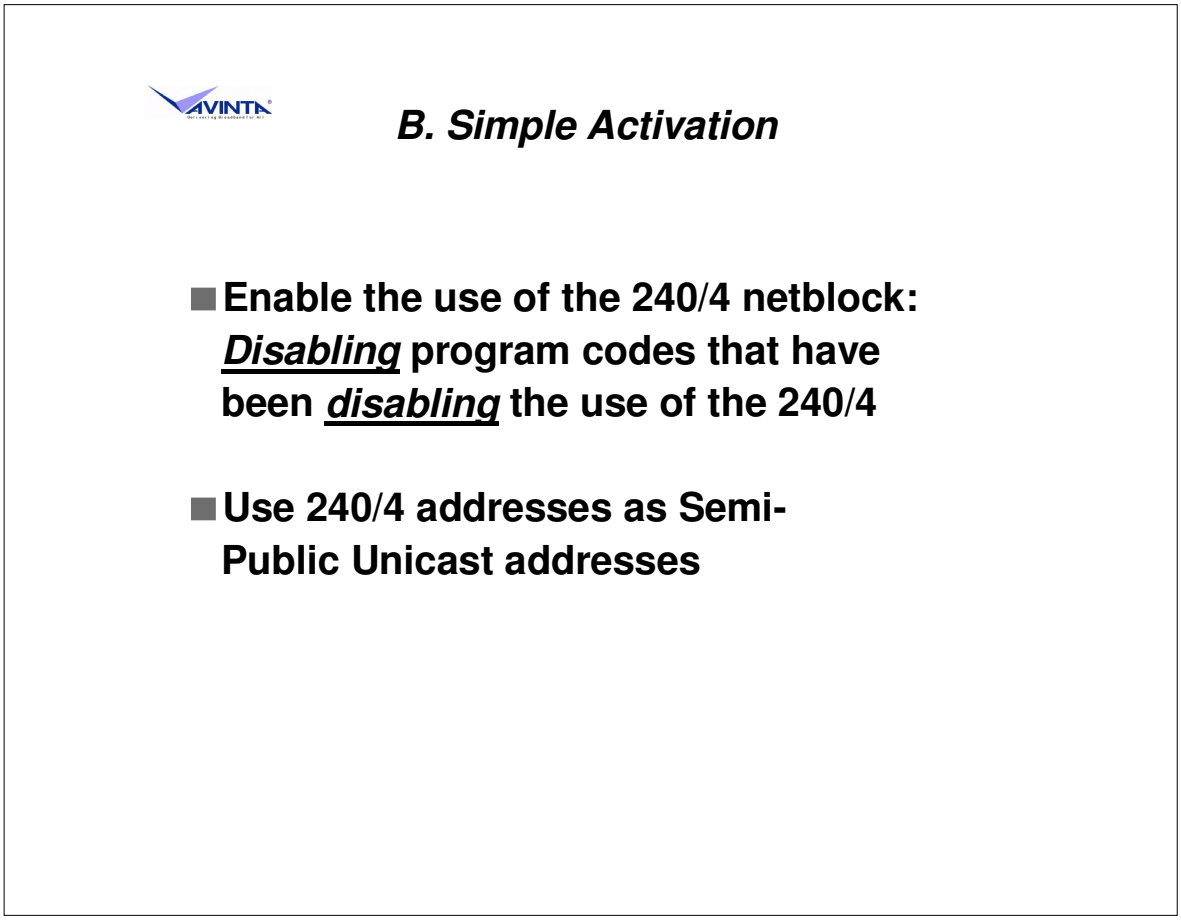
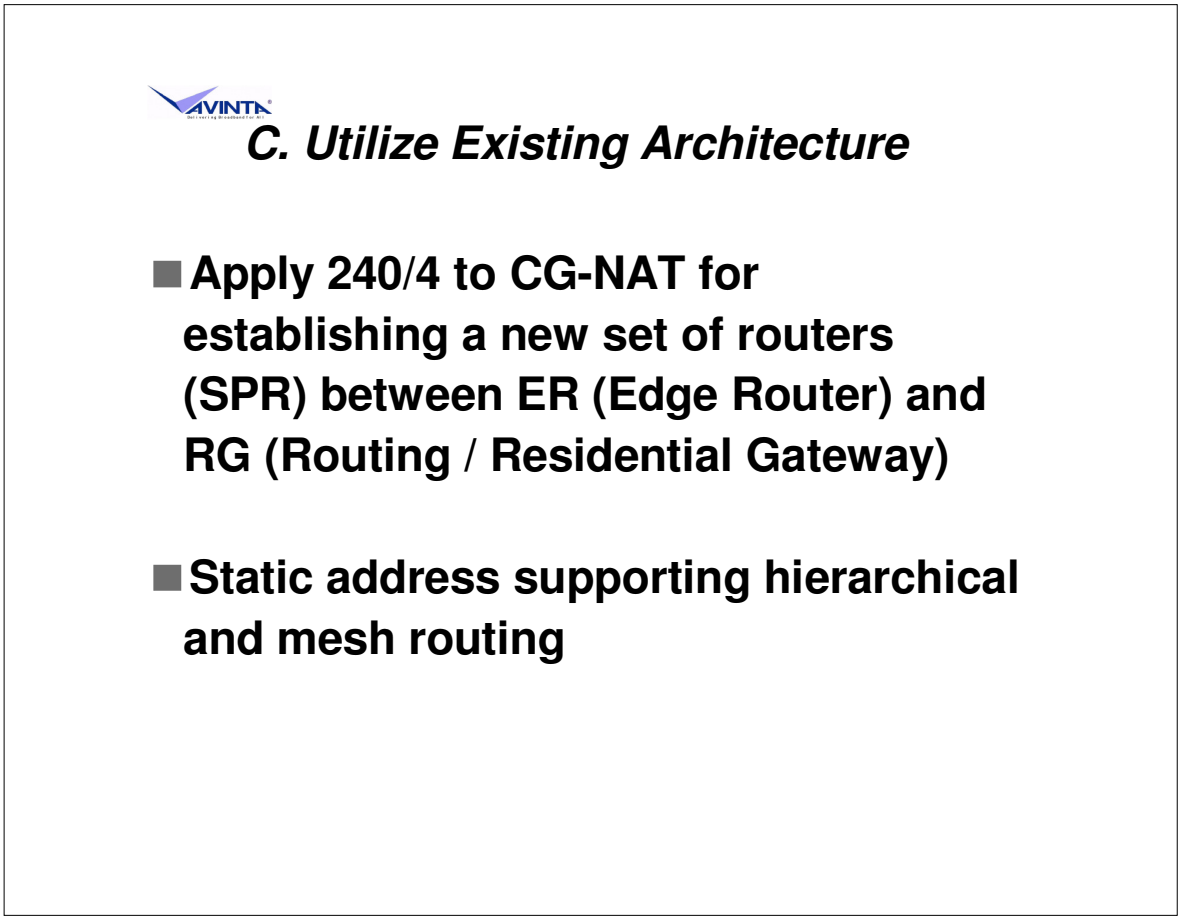
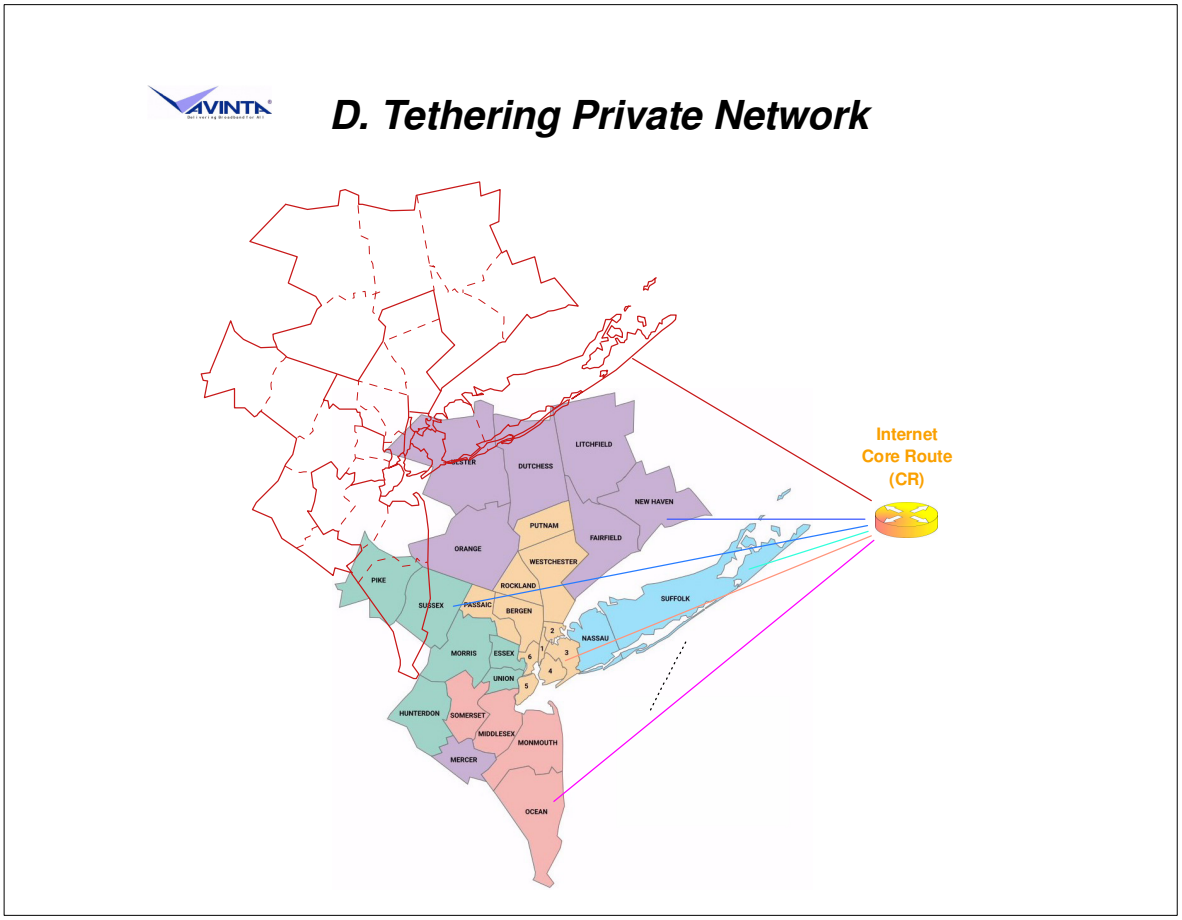


- Next, let's look at how this can be done.
- For a long time, networking equipment blocked packets with 240/4 address, making this netblock appear to be ***a mystery***. The actual mechanism is likely ***a very short screening code that recognizes the 240/4 address prefix in an IP header and then drops the packet.***
- We have identified ***one such example,*** that is, by ***commenting out one line code*** that has been disabling 240/4 addressed packets, the 240/4 is enabled.
- So, we should keep a mental note that software engineers claiming this is a complicated task may not know enough about their own program codes. Or, their code is not as concise.
- The 240/4 netblock should be used primarily for basic user identifications.



- Enhance CG-NAT routers to use 240/4 netblocks in addition to 100.64/10 to ***provide service in parallel***.
- Address pool of each SPR using 240/4 is large enough to cover up to ***64 CG-NAT clusters***.
- ***Static*** 240/4 address assignment ***simplifies record keeping and administration***.
- ***Static addressing supports hierarchical and mesh routing***.
- Note that the reverse, ***dynamic addressing can not support hierarchical routing.***



- One of the most ***rudimentary*** communications system functions is to provide ***peer communication (or end-to-end connectivity)*** for every subscriber. It requires every participant to have ***an unique static address.***
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- ***NYC Metro area*** consists of ***NYC five boroughs*** plus nearby counties in New York state as well as adjacent states of ***Connecticut, Pennsylvania and New Jersey***, with a ***total population of 23.5M***.
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- ***NYC itself*** with five boroughs, Bronx: 1.3M, Brooklyn: 2.7M, Manhattan: 1.7M, Queens: 2.2M, Staten Island: 0.5M, ***totaling 8M*** already exceeds the ***4M capacity of RFC6598 100.64/10 netblock***. With the tight knit among NYC five boroughs, everyone within NYC must have an IP address from the same address block to initiate communication to one another directly at will. Note: Hudson County, NJ is shown as the 6th part of NYC because it is very much integrated in the daily life through a separate subway system (PATH) under the Hudson River.
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- It is clear that the Internet needs ***multiple CG-NAT clusters to serve NYC Metro, let alone supporting peer communication.***
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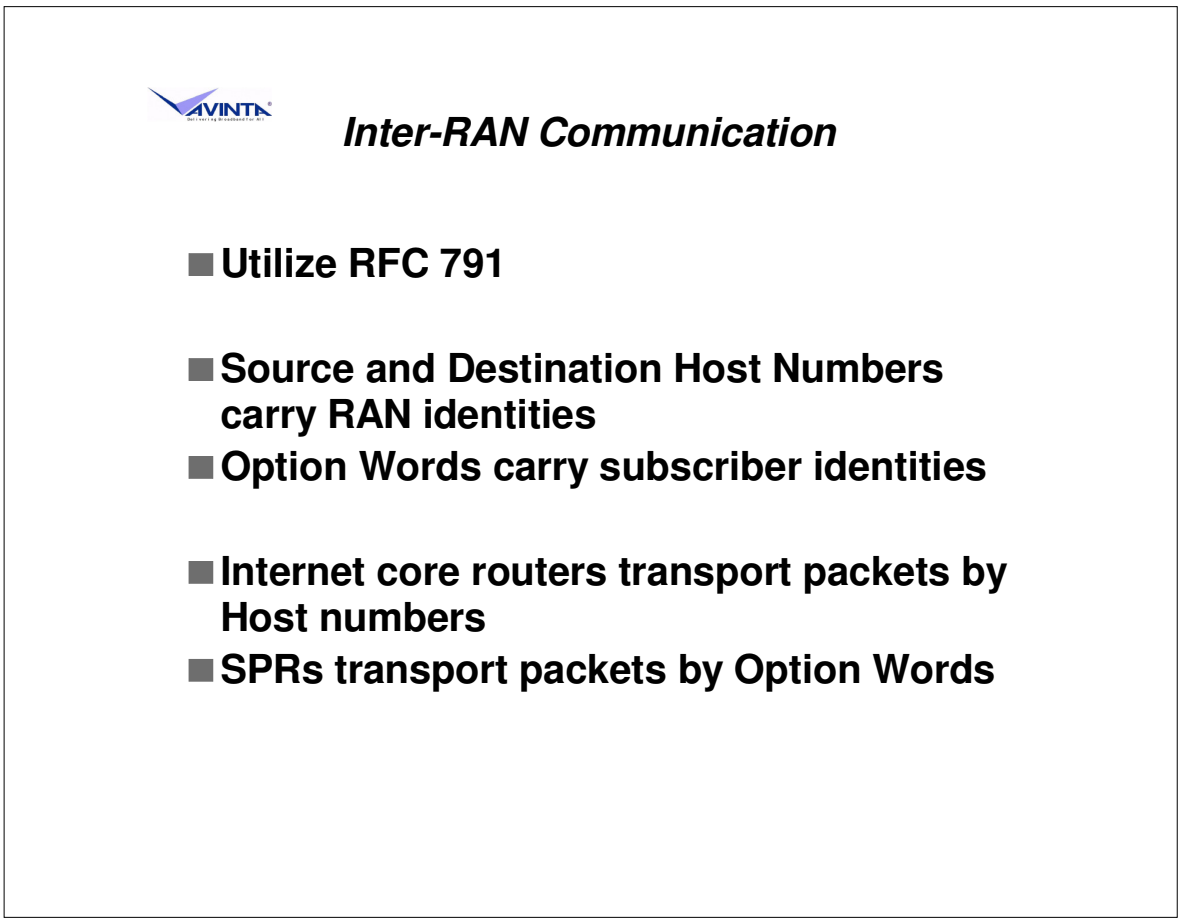
- An ***SPR island*** with ***one set of static 240/4 addresses*** is capable of serving ***the entire NYC Metro tethering over the existing Internet, with a lot of spare addresses.***
-
- Depending on the population of an intended service area, a ***RAN*** (Regional Area Network) may consist of ***one or more SPRs***

E. Overlay Network to The Internet

RANs form a Sub-Internet
called EzIP Network
Overlay the Internet core

- Each country has its respective ***RAN*** (Regional Area Network), ***most*** consisting of ***one SPR***. Combining ***RANs*** around the world form ***a sub-Internet,*** called the ***EzIP Network,***
- that overlays the Internet Core, allowing capabilities and functions ***within each RAN be independently developed***, as long as there are ***arm's-length links*** among them through the CR for ***inter-RAN communication***.
- To visualize this, let's look at this situation in ***a big picture,*** say from ***10K miles above the earth***.
- This graphics created by ***Dot-Connect-Africa*** depicting their long time ***disputes with ICANN about address allocation*** related issues. The ***floated African continent*** in the sky implies the disparity.
- Upon a closer look, ***continents beyond Africa are also floating in the sky***. So, this graphics may be interpreted as the ***EzIP Network*** (bronze-colored continents) hovering above (or overlaying) ***the existing Internet*** (the blue-colored globe coordinated by ICANN).



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►To establish end-to-end communications between subscribers located in separate RANs, RFC 791 will be utilized to form an IP Header:
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►a. Basic Source and Destination Host Numbers will carry the IP addresses of the two RANs.
►b. The Option words will carry the identities of the subscribers, either RGs or directly connected IoTs.
►
►Packets transit through the Internet core will use Host Numbers.
►Within a RAN, the Option words will direct the traffic.
►
►In brief, the above processes only require the use of "EzIP capable" IoTs and RGs by parties interested in the direct inter-RAN communication. These will be either new generation devices, or enhanced from those already used in phase one.
►
►SPRs in the RANs and Internet core devices linking RANs do not need be upgraded.
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►Overall, this is a case-by-case gradual roll-out of an advanced feature, starting from only limited few early adopters. This is very much analogous to the dial-up modem pair at either end of a telephone connection that enabled the rudimentary data communication over PSTN for technologists during late 1970s. Such scheme then benefited ordinary users with consumer products such as FAX machines that escalated the one-to-one novelty to an any-to-any commodity, thus popularized and sped up the deployment of the Internet.
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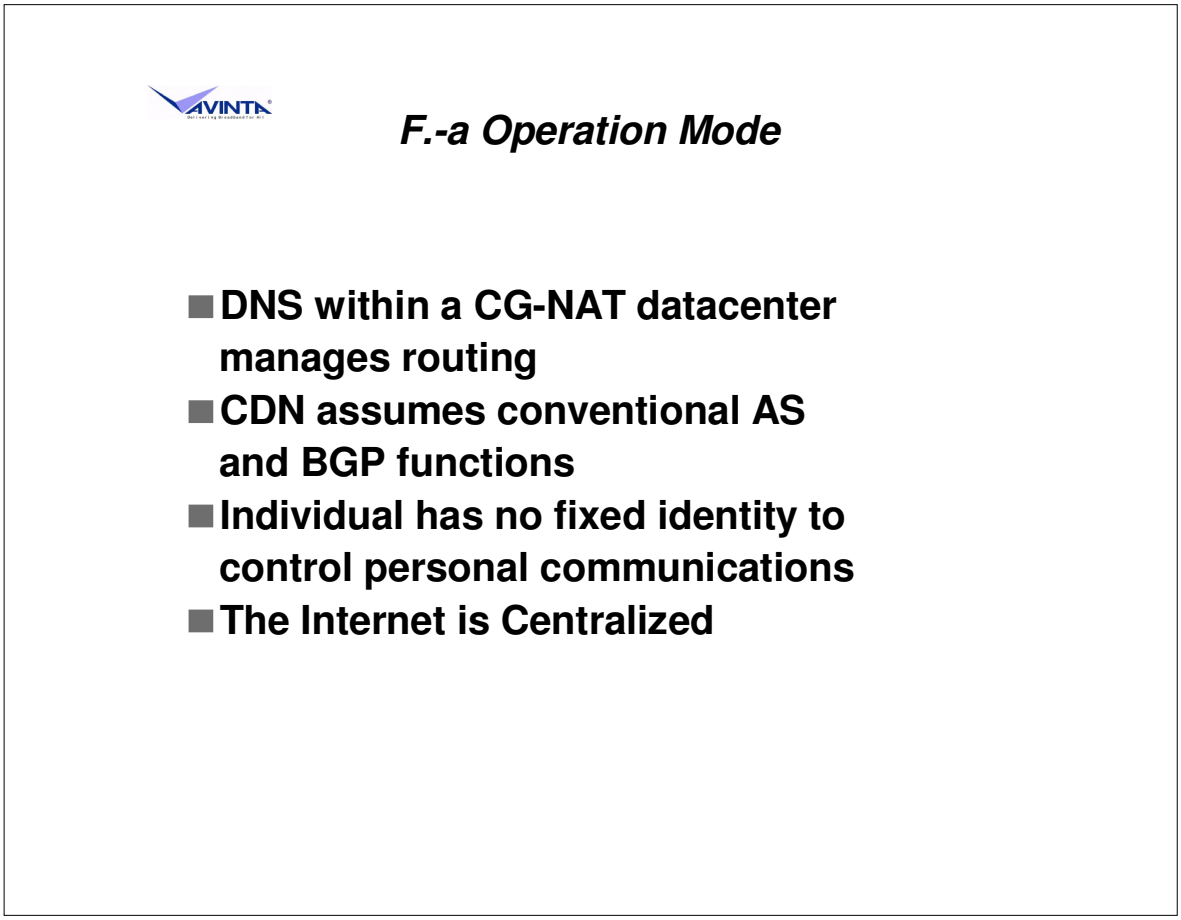

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► ***How many in the audience have heard of an Internet research activity, called "Decentralize the Internet?" If so, have you wondered why such a need? Wasn't everything in the Internet supposed to be dynamic and distributed, thus already decentralized?***
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■ Pioneered by search engines, ***distributed data centers were placed in or near key market***s for faster and more efficient response, etc. It was then adopted by content delivery services. This configuration serves CDN well by ***not only improving performances, but also lowering cost***.
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■ The side effect of this setup ***consolidates the routing services*** such as DNS into a local process in the CDN Gateways, reducing the reliance on AS and BGP functionality.
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■ From a casual user point of view, this configuration is fine for ordinary purposes such as ***entertainment.*** However, this scheme ***deprives users of the Individual identity*** that is essential to initiate and to manage ***personal communication*** with one another ***directly***, let alone the ***freedom to innovate independently.***
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■ Consequently, ***the Internet is Centralized.***
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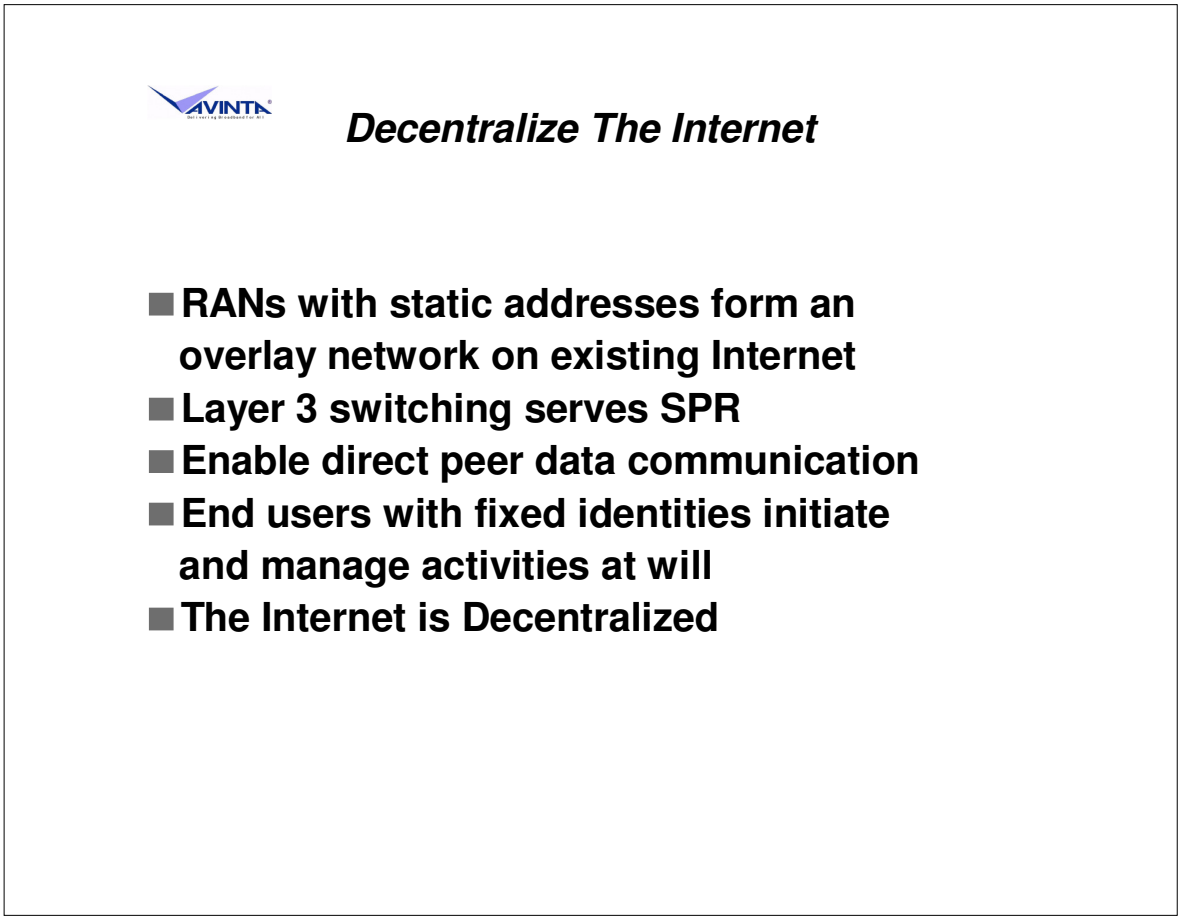
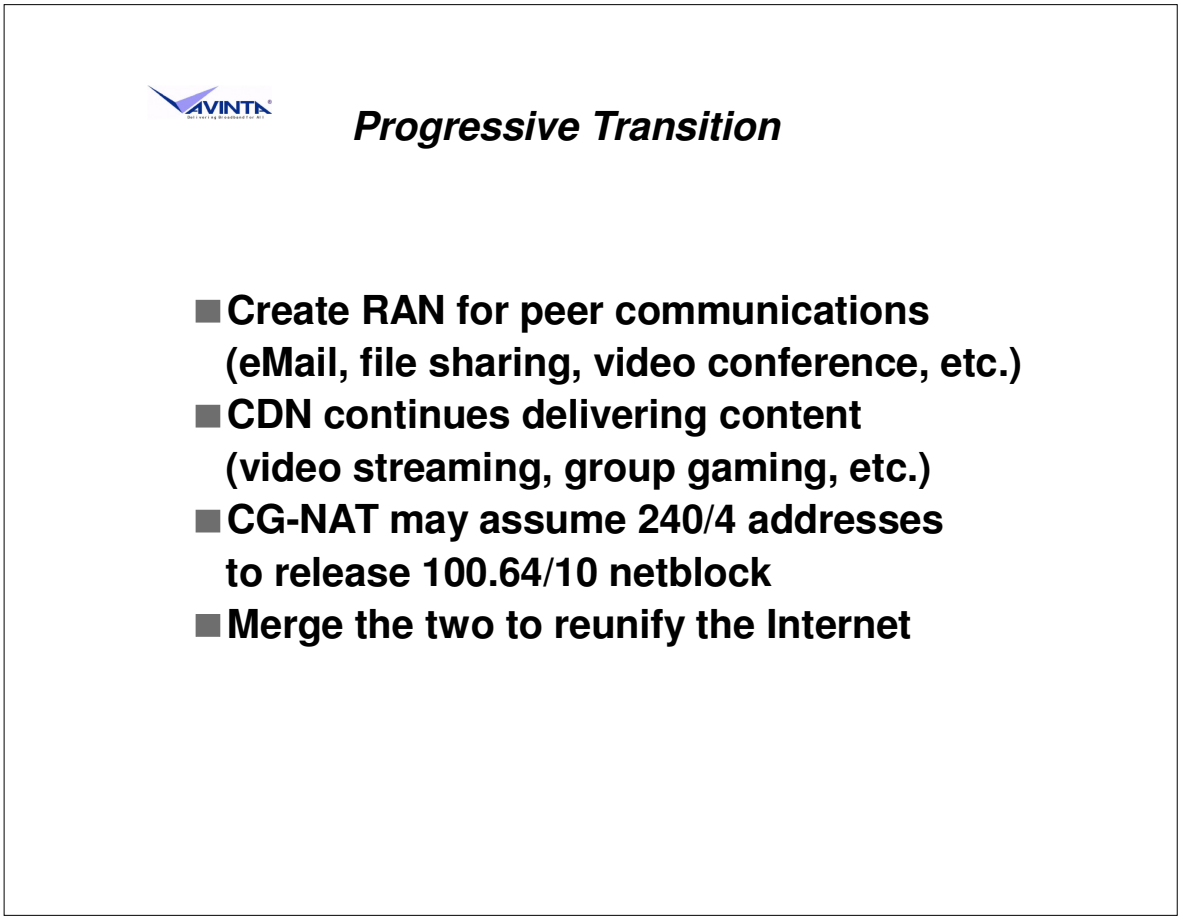


- Each SPR uses an IPv4 addressed transmission channel as an umbilical cord to access the Internet core.
- Unique static addresses enable ***direct L3 (Layer 3) switching*** among subscribers without relying on router service.
- Individuals are free to ***communicate with one another directly*** at will and to innovate.
- From a user's perspective, the Internet becomes truly a ***Decentralized communication backbone supporting individualism***.



►
►This proposal is not to create a new form of the Internet, but a temporary transition process.
►
■A ***RAN*** based facility is like the ***traditional postal and telephony*** message (Peer-to-Peer) services.
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■While the ***current Internet*** can focus on media distributions like the ***traditional broadcast and cable TV entertainment*** (Master-Slave) services.
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►
■Since ***dynamic based operations*** do not mind using static address, ***CG-NAT could adopt the same static 240/4 addresses*** that subscribes have been assigned by the RAN operation.
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►The ***100.64/10 netblock*** can then be ***released*** back to the ***general public address pool*** (originally allocated to ARIN).
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►
►
■Once each subscriber is assigned with ***the same IP address for both RAN & CDN*** services, the two networks can be **coordinated and merged,** as if they were one..
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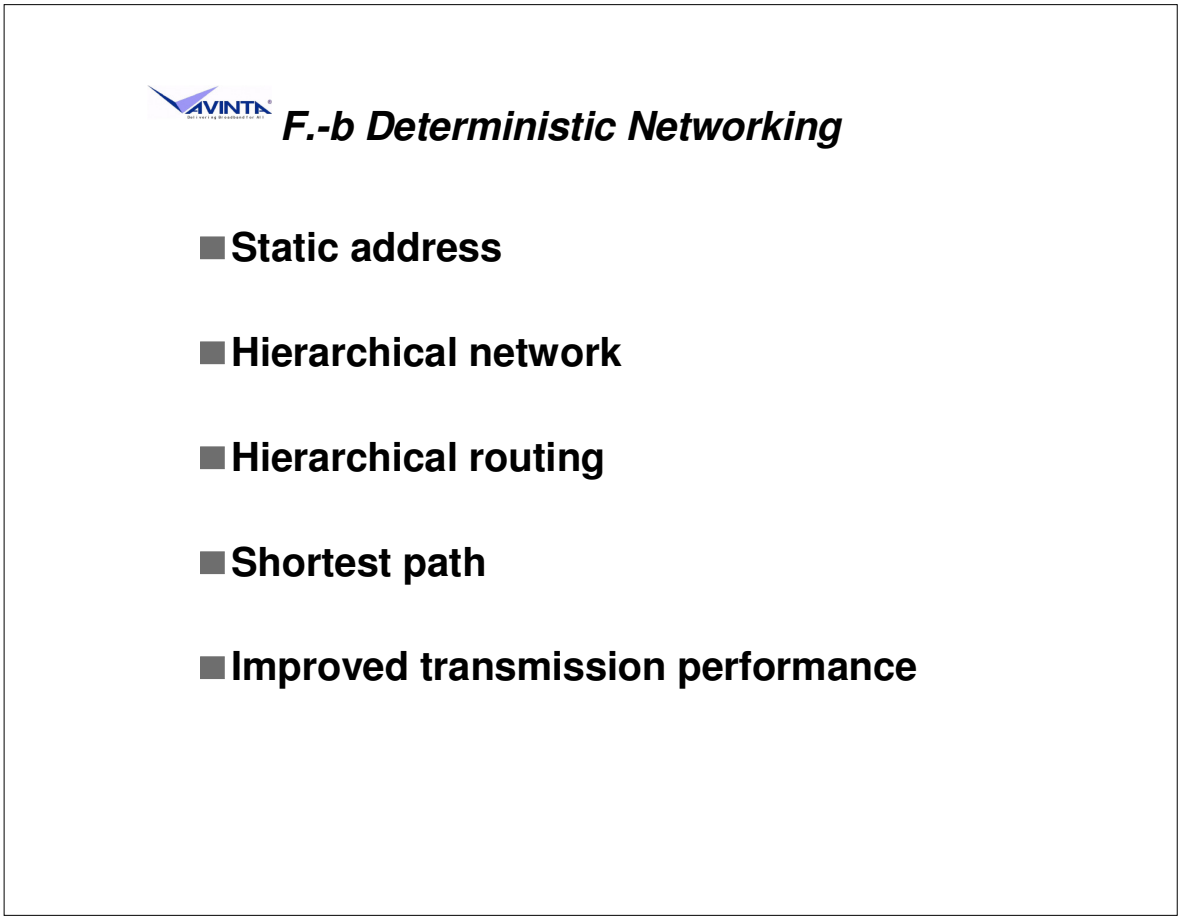
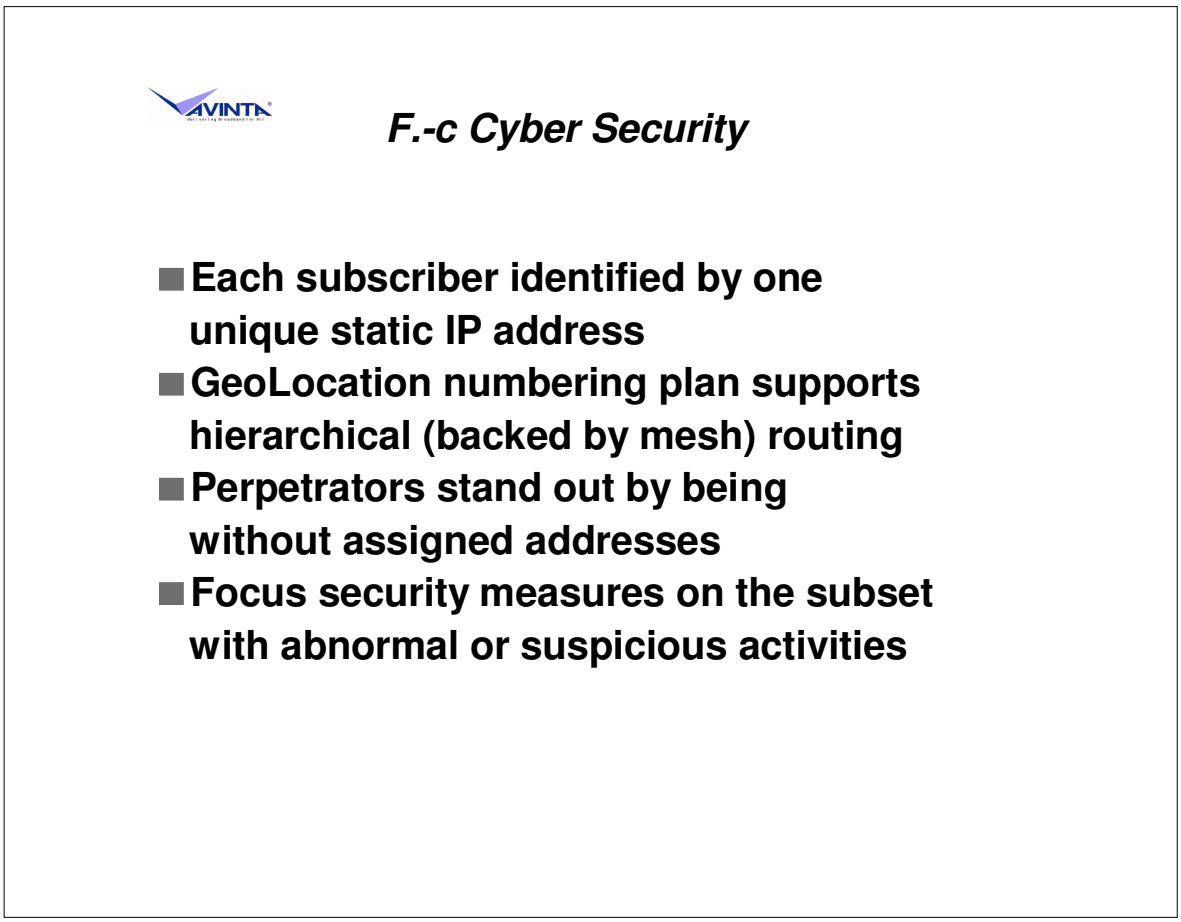
►The Internet is ***simplified, streamlined*** to enable a ***deterministic*** system that is ***robust against cyber intrusion.***
►



- The basic goal of EzIP network is to assign static addresses to all subscribers. This simplifies the administration as well as operations.
- Static address enables hierarchical network structure as well as routing. these basic operation facility will use the most direct path and shortest path for fastest delivery.
- This minimizes signal degradation and transmission errors.
- Current dynamic mesh routing may stay in place as the backup.



►Let's have a look at how EzIP could help improve cyber security

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■If each person is assigned with one IP address, an ***SPR*** can serve a population of 256M. A subscriber can be physically located by the IP address being used according to the subscription record.

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■Practicing GeoLocation disciplines, the ***address prefix in an IP heade***r identifies the general service area where the desired address belongs to. This guides routers to choose the ***most direct route to the destination area.***

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►Note: ***Mesh routing*** mechanisms can still be utilized as ***backup / redundant*** mechanism.

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■A none assigned IP address used by a perpetrator will not be able to get service from an SPR in the first place.

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►Even if a valid IP address is hijacked by a perpetrator to send an IP packet, the return packet will go to the legitimate subscriber on record.

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■Consequently, the "abnormal" portion of the Internet traffic will be greatly reduced, enabling security measures to be more effectively focused on suspicious packets..

G.-a Summary

- **Address expansion via 240/4 netblock**
- **Networking program code simplification**
- **Extend each IPv4 address by 256M fold**
- **Static and hierarchical network discipline**
- **Layer 3 switching for an SPR**
- **End-To-End connectivity within each SPR**
- **Overlay network tethering off Internet**

►

■ Note that 240/4 netblock should be regarded as ***shared public resources***, instead of commercialized by ***IAP (Internet Access Provider) as private properties.***

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■ Commenting out one line code that has been disabling the 240/4.

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■ 240/4 has the capacity of serving 256M premises from one public IPv4 address. The RFC1918 private network addresses (17.06M) can then be utilized by individual subscribers to expand respective private networks to handle on-premises IoTs.

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■ Static addressing supports hierarchical routing. But, dynamic addressing can not.

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■ Flat static address playing field allows routing by IP address or Layer 3 switching.

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■ Within each SPR, direct connection becomes feasible.

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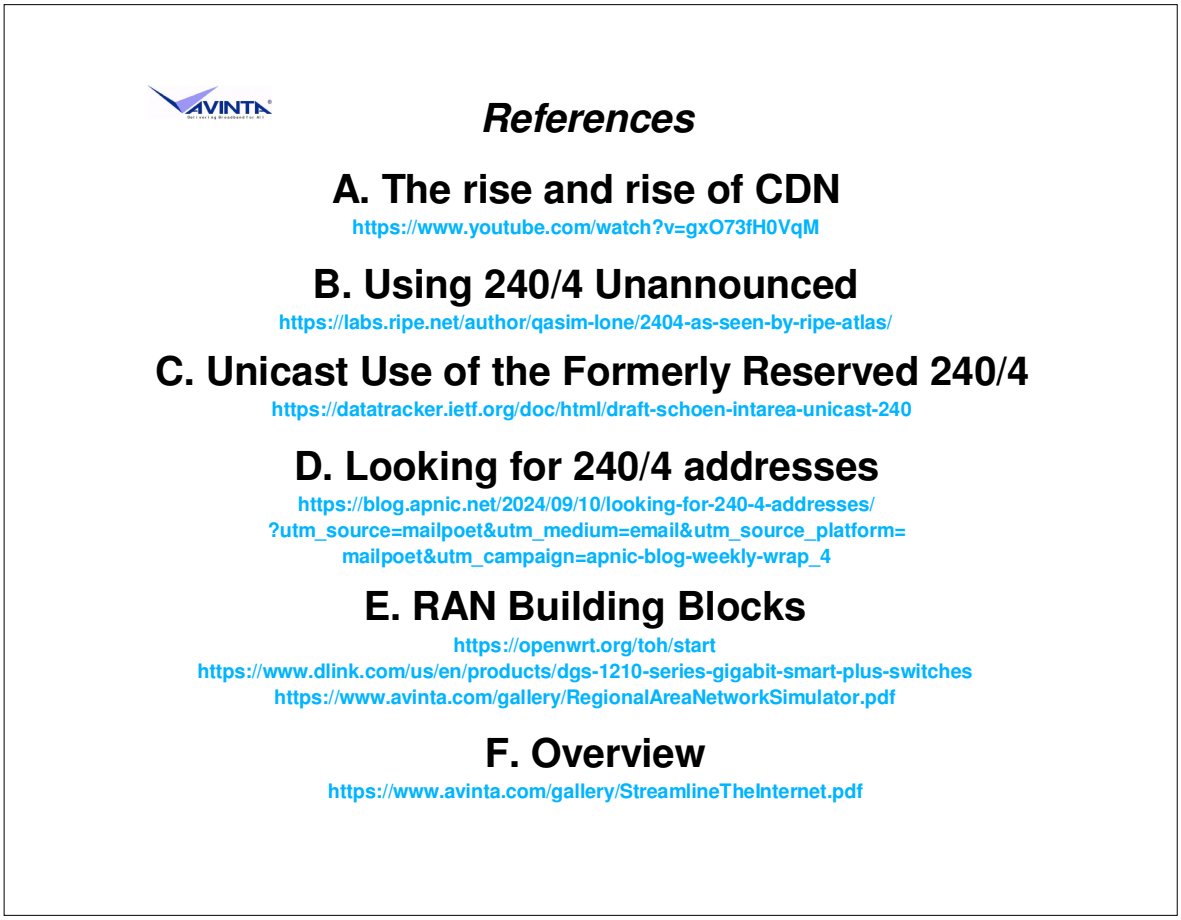
■ RAN appears to be tethering off the Internet with an umbilical cord and operating in parallel to while independent of the Internet core.

▸

G.-b Summary

- **RAN for peer messaging (Data & Video)**
- **CDN for entertainment (Streaming & Game)**
- **No more need for DHCP, DNS, AS and BGP**
- **A deterministic system lowers cost and expense**
- **Inherent GeoLocation property for stronger cyber security**
- **Utilize RFC791 for inter- RAN connections**

- RAN provides personal communications.
- CDN continues by focusing on entertainment.
- DHCP will still be useful for configuring new client devices. DNS degenerates to a quasi-static database equivalent to an electronic telephony WhitePages for lookup when needed. An SPR will not need AS nor BGP.
- Static addressing sets the foundation for a deterministic system that is easier to administrate. So that the overall cost and expense are reduced.
- Properly administrated static address provides GeoLocation property to ***discourage perpetrators***.
- Utilize ***RFC791 Option Word mechanism*** to route packets among RANs via ***two-level of IPv4 addresses (total of 64 bits)***. This is ***the same*** scheme as the ***country code prefixes for international telephony***. Since there are only ***about 200 sovereign jurisdictions*** (nations and entities) worldwide, ***two octets*** or half of one IPv4 address (64K combination) will be more than sufficient ***to identify all RANs***. The rest (the majority) can be used for identifying test beds, each established within an isolated environment.



- A. This ***APRICOT 2024 YouTube*** video describes the public communication evolution to become ***centralized around CDN***.
- B. This RIPE NCC (Réseaux IP Européens Network Coordination Centre -- ***Regional Internet Registry for Europe) - Lab*** article reports that ***multinational conglomerates*** have been using 240/4 unannounced. Since they are ***difficult to detect,*** it demonstrates that using ***240/4 is not perturbing normal Internet operations***.
- C. ***IPv4 Unicast Extension Project*** proposes to ***reclassify 240/4 formerly Class E***, among a few other netblocks, as ***Unicast*** for better utilization.
- D. This blog recounts the ***history of the 240/4 events***, reports recent measurements and concludes that it can be used as is, i.e., without IANA re-designation. This is because ***the existing Internet operations will not be disrupted***.
- E. These are OpenWrt open source code supported ***off-the-shelf networking equipment*** to operate with 240/4 netblock. The first are ***near 2.5K RG level devices***. These will ***buffer on-premises IoTs (including PCs)*** from the 240/4 environment. The ***D-Link GigaBit smart switch*** (up to 48+4 ports) can be used to start ***experimenting SPRs and forming RANs*** for guiding the upgrade of **current CG-NAT routers**. The third URL leads to diagrams depicting how these may be put together to start a RAN Simulator.
- F. This whitepaper summarizes the ***contradictions*** around the Internet and then describe the EzIP solution to streamline the Internet.

A Deterministic Internet

Questions?

Comments?

Next Step?

Thank You!

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- **Questions? .....**
- **Comments? .....**
- **Next Step?**
  - With ***building blocks available***, any technically competent person can ***deploy a RAN***, based on a static IPv4 address even by starting from one's basement or backyard, since the use of the ***240/4 netblock will not disturb the current Internet nor private network.*** This is analogous to how ***Dial-Up modem worked over the PSTN*** and ***UNIX based network routers quietly replaced those based on Windows***.
  - Please ***drop a line to us*** about your thoughts and activities, so that your experiences may be ***shared among parties with similar interests.***
- Lastly, allow me to share a ***layman's naive perspective***. That is, if we treated the Internet as ***a packetized PSTN*** so that the ***traditional communications disciplines*** were maintained, most of ***the Internet*** would become ***Deterministic,*** so that it may be more ***secure against cyber intrusions.***
- **Thank You!**