Getting Started with IPv6 on the Mainframe

Part 2 of 2

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Collaborative Project

- India Internet Engineering Society (IIESoc) and Industry Network Technology Council (INTC)
- Past Funding: Grant from ISIF Asia (APNIC Foundation), ARIN Community Grants
- Thank you!

https://www.iiesoc.in/

https://industrynetcouncil.org/

Vision

Multi-year project: IPv6 deployment at enterprises.

- Provide training,
- Analysis of security and application conversion,
- Help enterprises plan their IPv6 deployment.

Classes

- Getting Started with IPv6 on the Mainframe : Part 1: November 4, 2021
- Getting Started with IPv6 on the Mainframe : Part 2: November 18, 2021
- IPv6 and Evolving 5G Deployments: December 16, 2021

2022

- IPv6 and IoT (multiple sessions)
- More IPv6 security
- IPv6 and DDI (DNS, DHCP, IPAM) (two sessions)
- Internet Standards Bodies
- IPv6 case studies

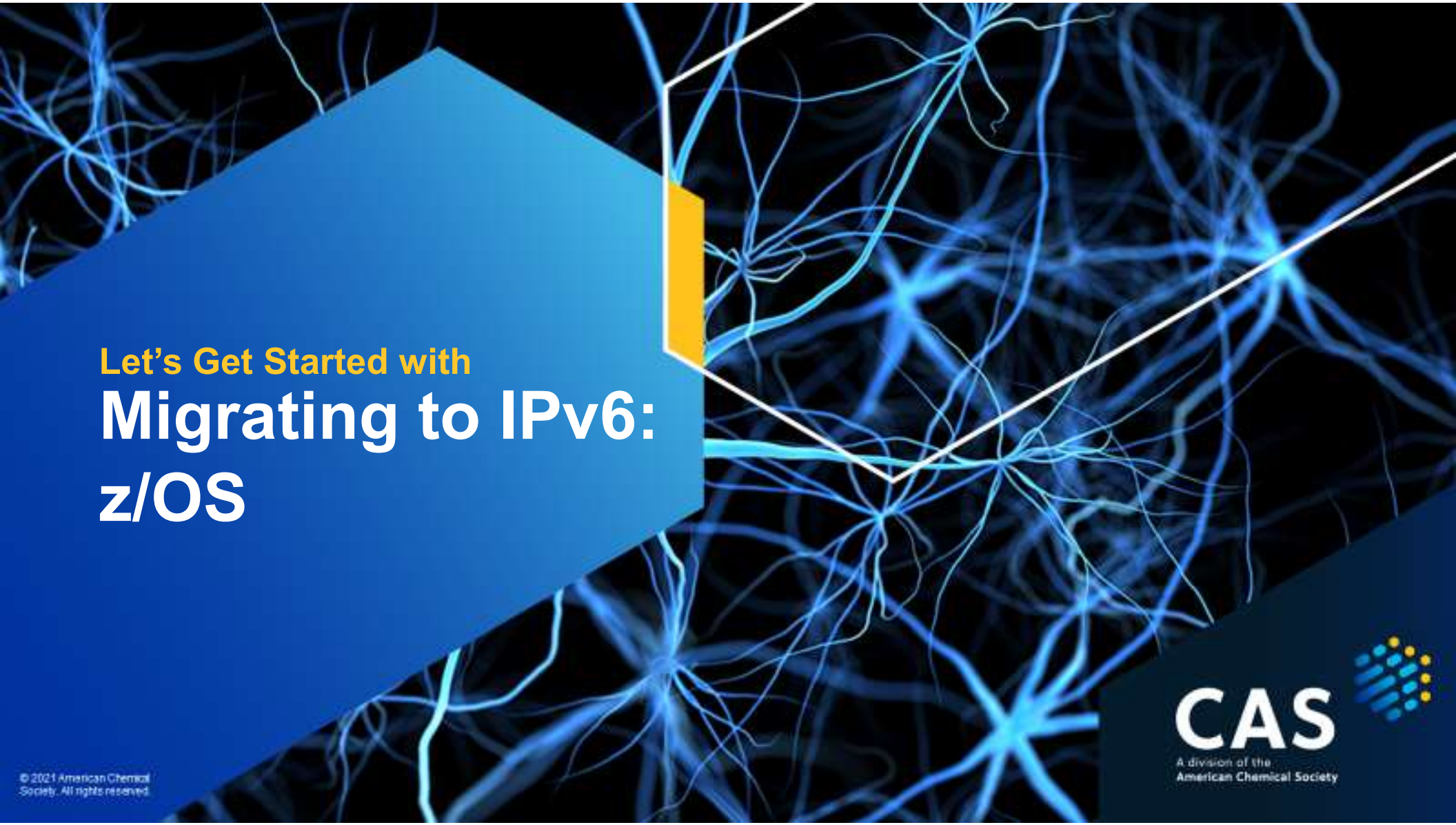
Send us requests!

A few words about me

- President: Industry Network Technology Council
- Founder & CEO: Inside Products, Inc.
- Advisory Board: India Internet Engineering Society
- RFCs: RFC8250 (Embedded performance and diagnostics for IPv6) and others
- Product developer (OEMed by IBM and others)
- Working with IPv6 for 15 years
- Working with network management, diagnostic, performance issues at large brick-and-mortar enterprises for over 30 years

A few words about Rob

- Rob started programming mainframe computers in 1971, and learned an exceptional array of languages, tools and techniques, all without internet assistance.
- He did some dazzling database work in the `80s and wrote over half of the first online registration system for the University of Toledo.
- In the ‘90s he did contracts with three oil companies, a software company and a credit bureau, involving VM, MVS, VSE, OS/2, several flavors of Unix, and an equal variety of networking protocols.
- He is now with Chemical Abstracts Service, a division of the American Chemical Society, supporting z/OS, z/VM and Linux, along with proprietary networking software.
- He has been involved with and a fan of IPv6 since early this century, performing the configuration and software upgrades required to support it on the mainframe.
- He happily notes that the mainframe was the first platform configured for it, with applications using IPv6 sockets exclusively.
- Rob is also co-author of RFC8250.



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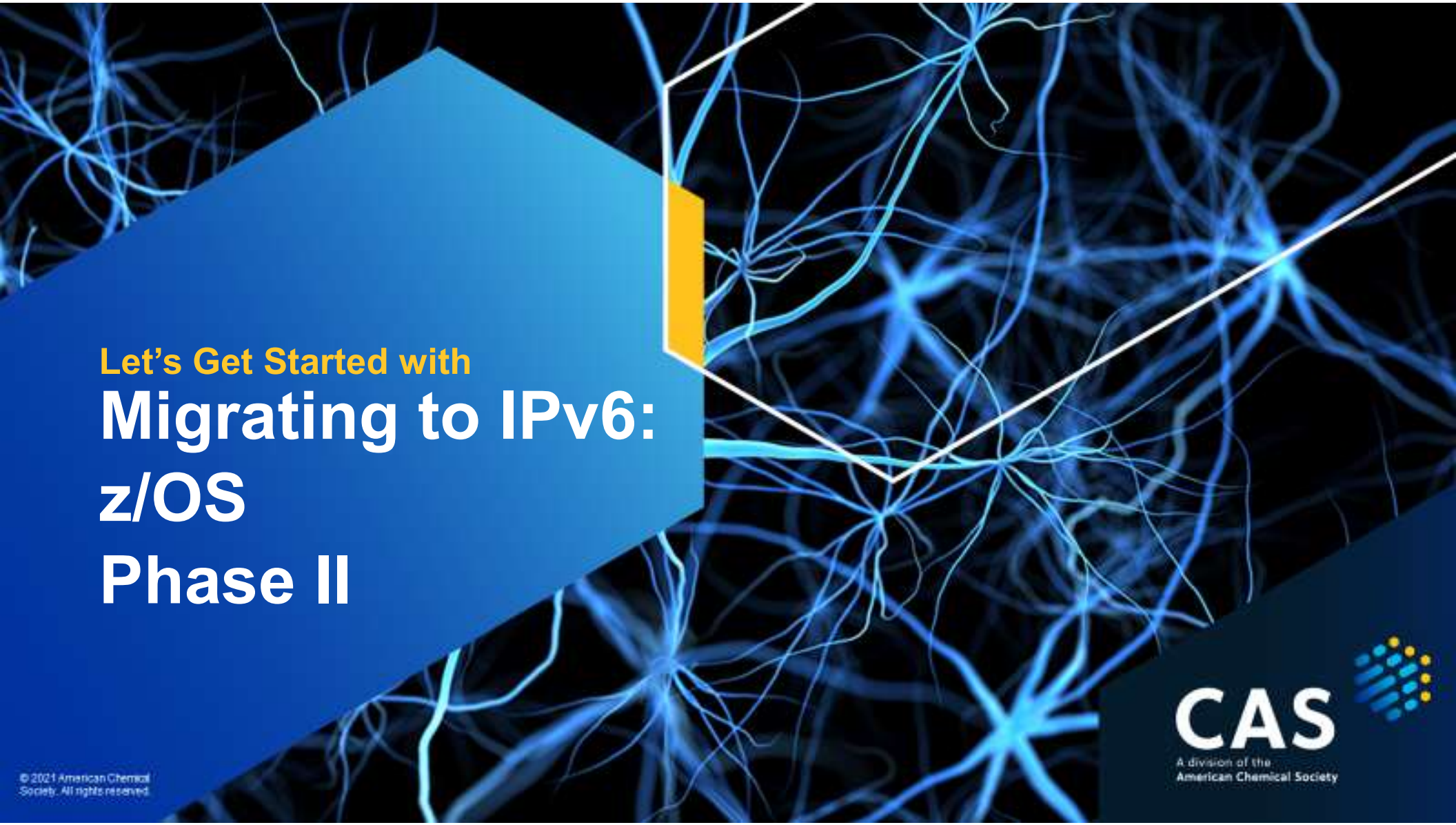

Migrating to IPv6: z/OS

DISCLAIMERS

- These are the steps I took in upgrading my z/OS IP stacks to use IPv6, generalized to make them look better. Your network may (most likely will) be different. The steps in these presentations will either get you there or get you well along on your migration journey. Your mileage may vary.
- As always, the IP addresses here that aren't publicly available have been changed, along with the names of other configurable items and hardware, to protect the guy who wrote this.

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Migrating to IPv6: z/OS

Here's What We Covered in Phase I:

- z/OS:
  - Planning
  - Enabling IPv6 Sockets
  - Configuring Name and Address Resolution

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Migrating to IPv6: z/OS

This is what is left to do:

- z/OS:
  - Configuring IPv6 Communications Components
    - Configure OSA INTERFACEs
    - Configure HiperSockets INTERFACEs
    - Configure primary and application VIPAs
    - Configure the IP side of Enterprise Extender
  - Configuring IPv4/IPv6 Routing

Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **Configure IPv6 Communication Components**

There are thirteen (13) statements you can use in your TCP/IP Profile for configuring IPv6…

I only needed three:

- **IPCONFIG6**
- **INTERFACE**
- **BEGINROUTES(/ENDROUTES)**

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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- To configure IPv4 communications you can use:
  - DEVICE
  - LINK
  - HOME
- You need all three to configure an IPv4 interface in “ye olde style”:

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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- To configure IPv4 communications you can use:

```
.
.
.
DEVICE OSA3     MPCIPA     NONROUTER
LINK   ETH34    IPAQENET   OSA3
.
.
.
HOME
your.ip.add.ress
.
.
.
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- To configure IPv6 communications you use:
  INTERFACE
- This one statement defines everything you need for IPv6, short of the routing:
  - Interface name
  - The PORTNAME specification from the VTAM TRLE
  - The IP address
  - The CHPID, for a HiperSockets network
  - Other IP characteristics, like SOURCEVIPAINT, SMCD and NONROUTER

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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- To configure IPv6 communications you use:

```
;
;
;
DEVICE OSA3     MPCIPA     NONROUTER
LINK   ETH34    IPAQENET   OSA3

INTERFACE     ETH36        DEFINE      IPAQENET6
     PORTNAME      OSA3
     IPADDR        7CC9:C2D4:0:2021::300:80
     SOURCEVIPAINTERFACE  MAINVIP6
     NONROUTER
;
;
;
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- What's really nice is:

```
.
.
.
INTERFACE     ETH34       DEFINE      IPAQENET
     PORTNAME     OSA3
     IPADDR       172.17.1.143/24
     SOURCEVIPAINTERFACE  MAINVIP4
     NONROUTER

INTERFACE     ETH36       DEFINE      IPAQENET6
     PORTNAME     OSA3
     IPADDR       7CC9:C2D4:0:2021::300:80
     SOURCEVIPAINTERFACE  MAINVIP6
     NONROUTER
.
.
.
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- To configure HiperSockets, it's similar:

```
.
.
.
DEVICE IUTIQD17   MPCIPA    AUTORestart
LINK   HPSCETH17  IPAQIDIO  IUTIQD17

INTERFACE     HS17ETH6     DEFINE      IPAQIDIO6
     CHPID         17
     IPADDR        7CC9:C2D4:FFFF:17::1:880
     SOURCEVIPAINTERFACE  HS17VIP6
.
.
.
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- Or, better:

```
.
.
.
INTERFACE     HS17ETH4     DEFINE      IPAQIDIO
     CHPID         17
     IPADDR        172.17.1.20/24
     SOURCEVIPAINTERFACE  HS17VIP4

INTERFACE     HS17ETH6     DEFINE      IPAQIDIO6
     CHPID         17
     IPADDR        7CC9:C2D4:FFFF:17::1:880
     SOURCEVIPAINTERFACE  HS17VIP6
.
.
.
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- Configuring primary VIPAs:

```
;
; MAINVIP4/MAINVIP6 are the main VIPAs for this system
;
; These two VIPAs need to be configured first, before interfaces
; that might reference them
;

  INTERFACE     MAINVIP4    DEFINE      VIRTUAL
       IPADDR       172.17.1.143

  INTERFACE     MAINVIP6    DEFINE      VIRTUAL6
       IPADDR       7CC9:C2D4:0:2021::40
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **Configuring application VIPAs:**

```
;
; virtual IP address definition for JE92M51S
;

  INTERFACE     M51SVIP4    DEFINE      VIRTUAL
       IPADDR       172.17.1.169

  INTERFACE     M51SVIP6    DEFINE      VIRTUAL6
       IPADDR       7CC9:C2D4:0:2021::8040
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **Configuring Enterprise Extender (IUTSAMEH):**

```
; Enterprise Extender configurables
;
; SAMEHOST device for Enterprise Extender
; IUTSAMEH represents an internal connection to VTAM
; MPCPTP6 is the corresponding IPv6 interface type
;
;   Note that all IUTSAMEH connections are on the same subnet
;

INTERFACE     MAINEEV6    DEFINE      VIRTUAL6
     IPADDR       7CC9:C2D4:FFEE:5::490

DEVICE IUTSAMEH   MPCPTP
LINK   EELINK4    MPCPTP    IUTSAMEH

INTERFACE     EELINK6     DEFINE      MPCPTP6
     TRLENAME     IUTSAMEH
     SOURCEVIPAINTERFACE  MAINEEV6
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **Dynamic TRLEs – HiperSockets and IUTSAMEH:**

```
D NET,ID=ISTTRL,E
IST097I DISPLAY ACCEPTED
IST075I NAME = ISTTRL, TYPE = TRL MAJOR NODE
IST1314I TRLE = IUT00062   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUT01350   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUTIQDD3   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQ4D3   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUT00024   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUT01150   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUT01050   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUT01550   STATUS = ACTIV       CONTROL = ISM
IST1314I TRLE = IUTIQDD5   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQ4D5   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQDD1   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQ4D1   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQDD0   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQ4D0   STATUS = ACTIV       CONTROL = MPC
IST1314I TRLE = IUTIQDIO   STATUS = NEVAC       CONTROL = MPC
IST1314I TRLE = IUTSAMEH   STATUS = ACTIV       CONTROL = MPC
IST314I END
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **IUTSAMEH TRLE:**

```
D NET,ID=IUTSAMEH,E
IST097I DISPLAY ACCEPTED
IST075I NAME = IUTSAMEH, TYPE = TRLE
IST486I STATUS= ACTIV, DESIRED STATE= ACTIV
IST087I TYPE = LEASED             , CONTROL = MPC , HPDT = YES
IST1954I TRL MAJOR NODE = ISTTRL
IST1715I MPCLEVEL = HPDT       MPCUSAGE = SHARE
IST1717I ULPID = TCPIP0 ULP INTERFACE = *NA*
IST1717I ULPID = EEXCAM4 ULP INTERFACE = *NA*
IST1717I ULPID = EEXCAM4 ULP INTERFACE = *NA*
IST1717I ULPID = EEXCAM4 ULP INTERFACE = *NA*
IST1717I ULPID = EEXCAM4 ULP INTERFACE = *NA*
IST1717I ULPID = TCPIP1 ULP INTERFACE = *NA*
IST1500I STATE TRACE = OFF
IST314I END
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- **EE XCA Major Node:**

```
D NET,ID=EEXCAM4,E
IST097I DISPLAY ACCEPTED
IST075I NAME = EEXCAM4, TYPE = XCA MAJOR NODE
IST486I STATUS= ACTIV, DESIRED STATE= ACTIV
IST1679I MEDIUM = HPRIP
IST1685I TCP/IP JOB NAME = TCPIP1
IST924I -------------------------------------------------------------
IST089I EEHSGRP TYPE = LINE GROUP       , ACTIV
IST1680I LOCAL IP ADDRESS 192.172.1.213
IST1910I LOCAL HOSTNAME M24JVV4.CAS.ORG
IST924I -------------------------------------------------------------
IST089I EEHSGP6 TYPE = LINE GROUP       , ACTIV
IST1680I LOCAL IP ADDRESS 7CC9:C2D4:FFFF:B4::40
IST1910I LOCAL HOSTNAME M24JVV6.CAS.ORG
IST924I -------------------------------------------------------------
IST089I EEOSAGRP TYPE = LINE GROUP       , ACTIV
IST1680I LOCAL IP ADDRESS 172.17.1.143
IST1910I LOCAL HOSTNAME MAINFRAME24JV4.CAS.ORG
IST924I -------------------------------------------------------------
IST089I EEOSAGP6 TYPE = LINE GROUP       , ACTIV
IST1680I LOCAL IP ADDRESS 2620:10:A000:69::40
IST1910I LOCAL HOSTNAME M24JV6.CAS.ORG
IST924I -------------------------------------------------------------
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- Routing for z/OS
  - Support for the GATEWAY statement was removed in z/OS V2R2
  - You must use BEGINROUTES and ENDROUTES
  - GATEWAY is still supported in z/VM as the statement that defines the routing table

Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- This is what the GATEWAY syntax looked like:

```
GATEWAY
; Network     FirstHop  LinkName  PacketSize  Subnet Mask  Subnet Value
  172.17        =         ETH3      1492        0.0.255.0    0.0.100.0
  172.17        =         ETH1      1492        0.0.255.0    0.0.100.0
; Default Route - All packets to an unknown destination are routed
;                 through these routes.
;
; Destination  First Hop         Link Name  Packet Size
; DEFAULT        172.17.100.254   ETH1       1492           0
; DEFAULT        172.17.100.254   ETH3       1492           0
```


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Migrating to IPv6: z/OS

What do we have to do: Configure TCP/IP for IPv6

- The analogous BEGINROUTES looks like this:

```
BEGINROUTES
;
; Direct Routes - Routes that are directly connected to my interfaces
;
;      Destination Subnet Mask   First Hop    Link Name Packet Size
ROUTE  172.17.0.0/16             =            ETH14     MTU 1492
ROUTE  172.17.0.0/16             =            ETH34     MTU 1492
;
ROUTE  7CC9:C2D4:0:2021::/64     =            ETH36     MTU 1500
ROUTE  7CC9:C2D4:0:2021::/64     =            ETH16     MTU 1500
;
;      Destination       First Hop        Link Name Packet Size
;ROUTE  DEFAULT           172.17.100.254   ETH14     MTU 1492
;ROUTE  DEFAULT           172.17.100.254   ETH34     MTU 1492
;
ENDROUTES
```


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Migrating to IPv6: z/OS

Migration: Timeline

- **May, 2005:**
  US Office of Management and Budget (OMB) instructs federal agencies to "begin addressing key IPv6 planning considerations."

- **August, 2005:**
  A guidance was issued by the General Accounting Office (GAO) that included a deadline of June 2008 for all government agencies to convert their network backbones to IPv6.

Migrating to IPv6: z/OS

Migration: Timeline – Beginning

- **April, 2008:**
  - **Began experimenting with enabling IPv6 sockets in BPXParms**
- **September, 2008:**
  - **Began working on the program updates required to use IPv6 sockets.**

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Migrating to IPv6: z/OS

Migration: Timeline – Configuration Complete

- **February, 2012:**
  All stacks configured to use IPv6

- **Primary Production z/OS system:**
  - **IPv6 sockets enabled in BPXParm in February, 2010**
  - **IPCONFIG6 added to TCP/IP Profile at the end of 2009**
  - **IPv6 INTERFACEs configured and routing added to primary stack in November, 2011; to the secure stack in February, 2012**
  - **All IPv4 DEVICE/LINK/HOME specifications changed to INTERFACEs in August/September, 2017**

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Migrating to IPv6: z/OS

Migration: Timeline – Software Migration Complete

- Socket-Management API
  - Originally consisted of 13 API routines
    - Encapsulates all socket calls (EZASMI)
  - IPv6 implementation began in September, 2008
    - When development began there were 17 routines
  - IPv6 development complete by December, 2010
    - Some tweaking/improvements until August, 2012
    - When development complete, there were 24 routines

Migrating to IPv6: z/OS

Migration: Timeline – Software Migration Complete

- **Application: Telnet Server**
  - **A front-end to a legacy product**
  - **Development began in February, 2011**
  - **Development complete in March, 2014**
    - **Message-handling and other changes made; this was actually a massive upgrade**
    - **Later changes made to the GateWay product were implemented here as improvements**
    - **The actual IPv6 implementation took about six months, thanks to the IPv6 encapsulation in the Socket API**

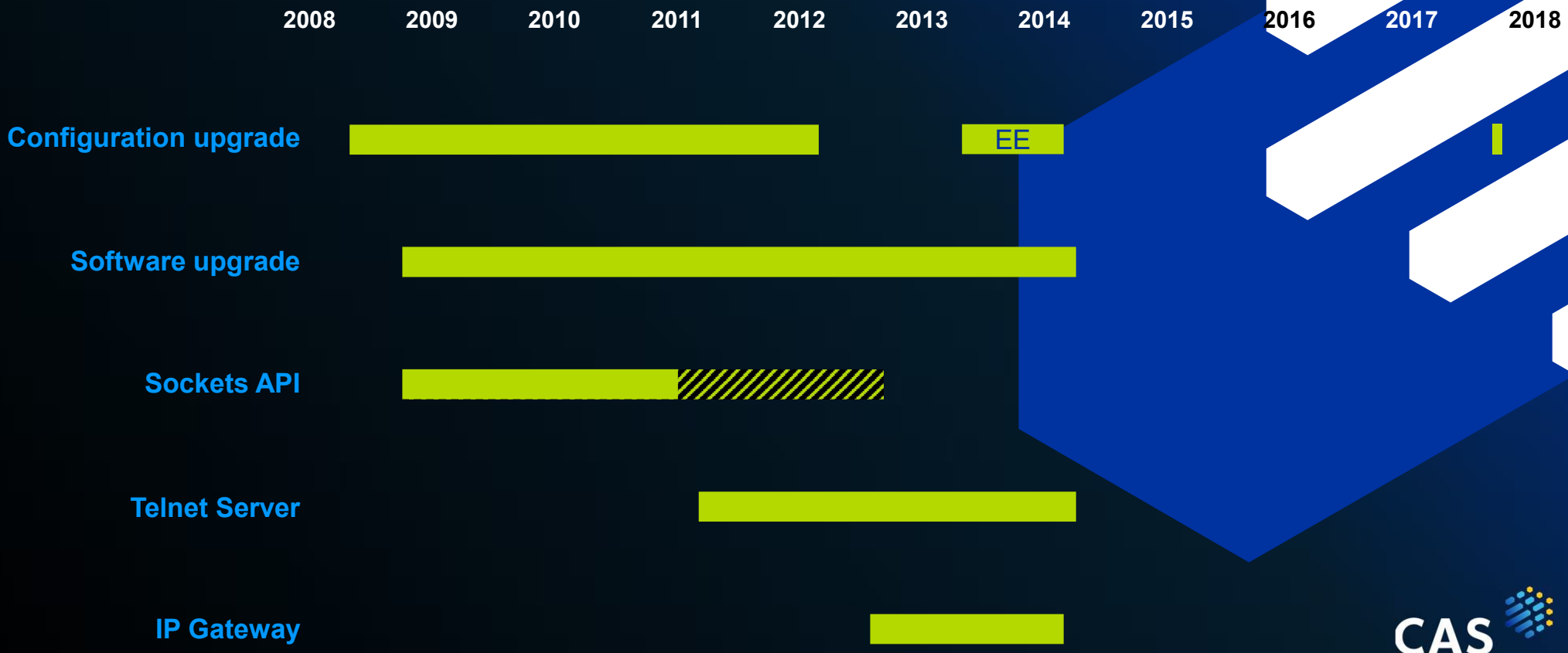
Migrating to IPv6: z/OS

Migration: Timeline – Software Migration Complete

- Application: IP GateWay
  - Encapsulates our proprietary network protocol in TCP sockets
  - Development began in July, 2012
  - Development complete in February, 2014
    - Again, this was a big upgrade, including the same message-handling and other changes made to the Telnet server
    - The IPv6 implementation was even faster than with the Telnet server, thanks to the lessons learned there

Migrating to IPv6: z/OS

Migration: Timeline



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Migrating to IPv6: z/OS

Here's What We've Covered:

- z/OS:
  - Planning
  - Enabling IPv6 Sockets
  - Configuring Name and Address Resolution
  - Configuring IPv6 INTERFACEs and Enterprise Extender
  - Configuring IPv4/IPv6 Routing

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Migrating to IPv6: z/OS

Questions?

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Thank you!!!

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