PXE
Preboot eXecution Environment

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Agenda

- PXE Overview
- System Requirements
- PXE Basic Operation
- DHCP Overview
- PXE DHCP Extensions
- PXE APIs
- Network Bootstrap Program
- Product Development Kit

PXE Overview

- What is PXE?
- PXE Vision
- Why is PXE Important
- PXE Industry Status
- Definitions

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What is PXE?

- PXE is a boot rom which uses the DHCP and TFTP protocols
- PXE is implemented as an “Option ROM”
  - “Video BIOS” and “SCSI BIOS” are other examples of “Option ROMs”
  - PXE could be described as an implementation of the “PXE BIOS”
- PXE is physically located either
  - On the NIC (in flash or ROM)
  - In the same memory as the system BIOS

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PXE Vision

"Make the Network Interface an Industry Standard PC Boot Device"

(The Network Interface becomes a boot device in the same sense that a hard drive, floppy, or CD-ROM is a boot device)

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Why is PXE Important?

- Standard Remote New System Setup
  - Remote OS installation
  - Remote BIOS Update
  - Remote CMOS Configuration
- Standard Remote Pre-OS Management
  - Via “Remote Wake Up”
  - On Demand
- Standard Remote OS Boot
  - Windows NT* 5.0

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PXE Industry Status

- Major OEMs are implementing PXE
- All Intel “LAN Down” Motherboards will include PXE
- ISVs are actively implementing PXE Boot ROMs
  - Incom
    - http://www.incom.de/
  - Lanworks
    - http://www.lanworks.com/

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Specifications Requiring PXE

- **Wired for Management Baseline Specification, Version 1.1a**
  Intel Specification
  - **http://www.intel.com/managedpc/wired/wfm_spec.htm**
- **Network PC Design Guidelines, Version 1.0b**
  Intel/Microsoft/Compaq/Dell/HP Specification
  - **http://developer.intel.com/design/netpc/netovr.htm**
  - **http://www.microsoft.com/hwdev/netpc.htm**
- **PC98 System Design Guide, Version 1.0**
  Intel/Microsoft Specification
  - **http://www.microsoft.com/hwdev/pc98.htm**
  - **http://developer.intel.com/design/pc98/**

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KADs (Key Acronym Definitions)

- **PXE**
  - *Preboot eXecution Environment*
    (Network PC and WFM remote boot capability)
- **LSA**
  - *LANDesk® Service Agent*
    (Intel's implementation of PXE)
- **NBP**
  - *Network Bootstrap Program*
    (The remote boot executable)
- **DHCP**
  - *Dynamic Host Configuration Protocol*
    (Used to get NBP name and location, etc., from configuration server)
- **TFTP**
  - *Trivial File Transport Protocol*
    (Used to download NBP from TFTP server)
- **MTFPT**
  - *Multicast* TFTP
    (Used to download NBP to many clients simultaneously)
- **UNDI**
  - *Universal NIC Driver Interface*
    (A PXE API that provides a device independent network interface to the NBP)
- **proxyDHCP**
  - "fake" DHCP
    (Extended DHCP service)
- **BINL**
  - *Boot Intervention Network Layer*
    (Mode of proxyDHCP service)

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PXE System Requirements

- Required BIOS Support
- Remote Wake Up

BIOS Support Needed

- BIOS Boot Spec. ver 1.01 (or greater)
- PCI BIOS Spec. ver 2.1 (or greater) and/or
- PnP BIOS Spec. ver 1.0A (or greater)

BIOS Support Needed

- Int 18h boot device support, including ability to put Int 18h device first in boot order
- For PXE in a Lan On Motherboard implementation, the system BIOS must support Int 15, Service 87 Extended Memory Move call during BIOS initialization
- BIOS support for GUID must be provided per the Network PC Design Guidelines Ver 1.0b

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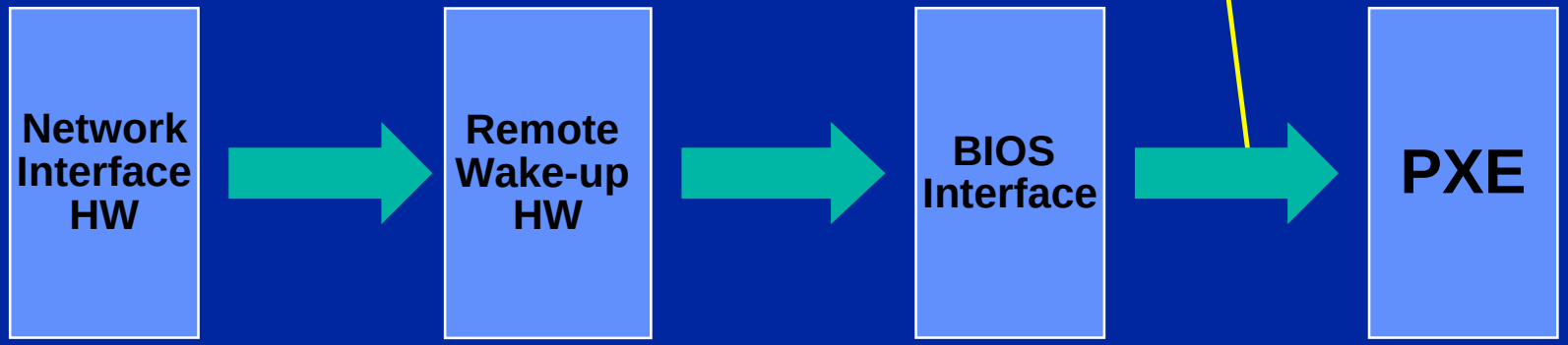
Remote Wake-Up

The system BIOS must indicate Boot Source by providing Int 15 (AX = 2307h) Service

- CL (bits 2-0) := 6 (Power Switch)
- CL (bits 2-0) := 5 (LAN)
- CL (bits 2-0) := 4 (COM1 RING)
- CL (bits 2-0) := 3 (Timer)



Remote Wake-Up

- For PXE in a Lan On Motherboard that includes Remote Wakeup support, the system BIOS must indicate Boot Source by providing Int 15 (AX = 2307h) Service
  - CL (bits 2-0) := 6 (Power Switch)
  - CL (bits 2-0) := 5 (LAN)
  - CL (bits 2-0) := 4 (COM1 RING)
  - CL (bits 2-0) := 3 (Timer)

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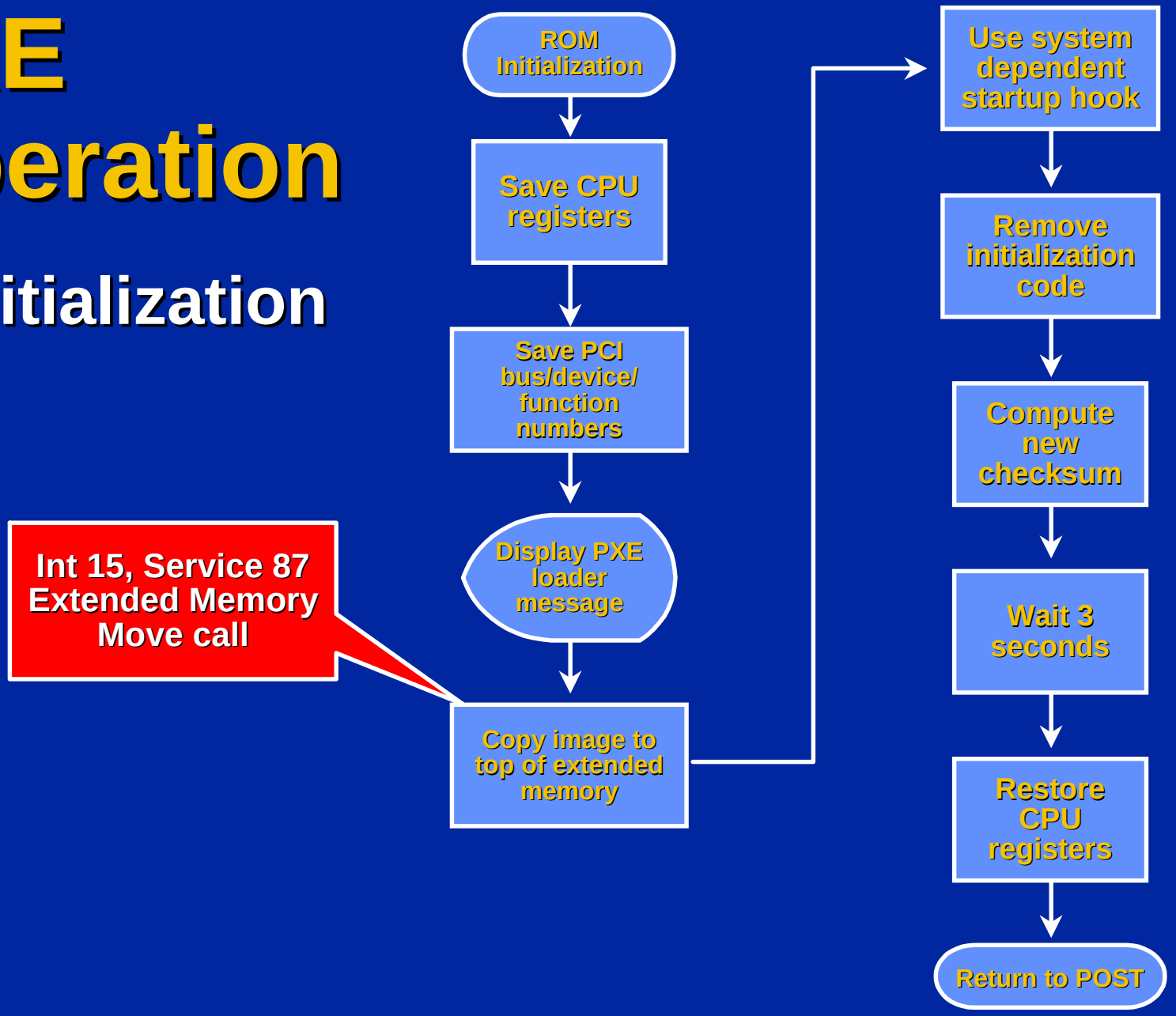
PXE Operation

- Initialization
- Boot
- Client State at Bootstrap Execution Time

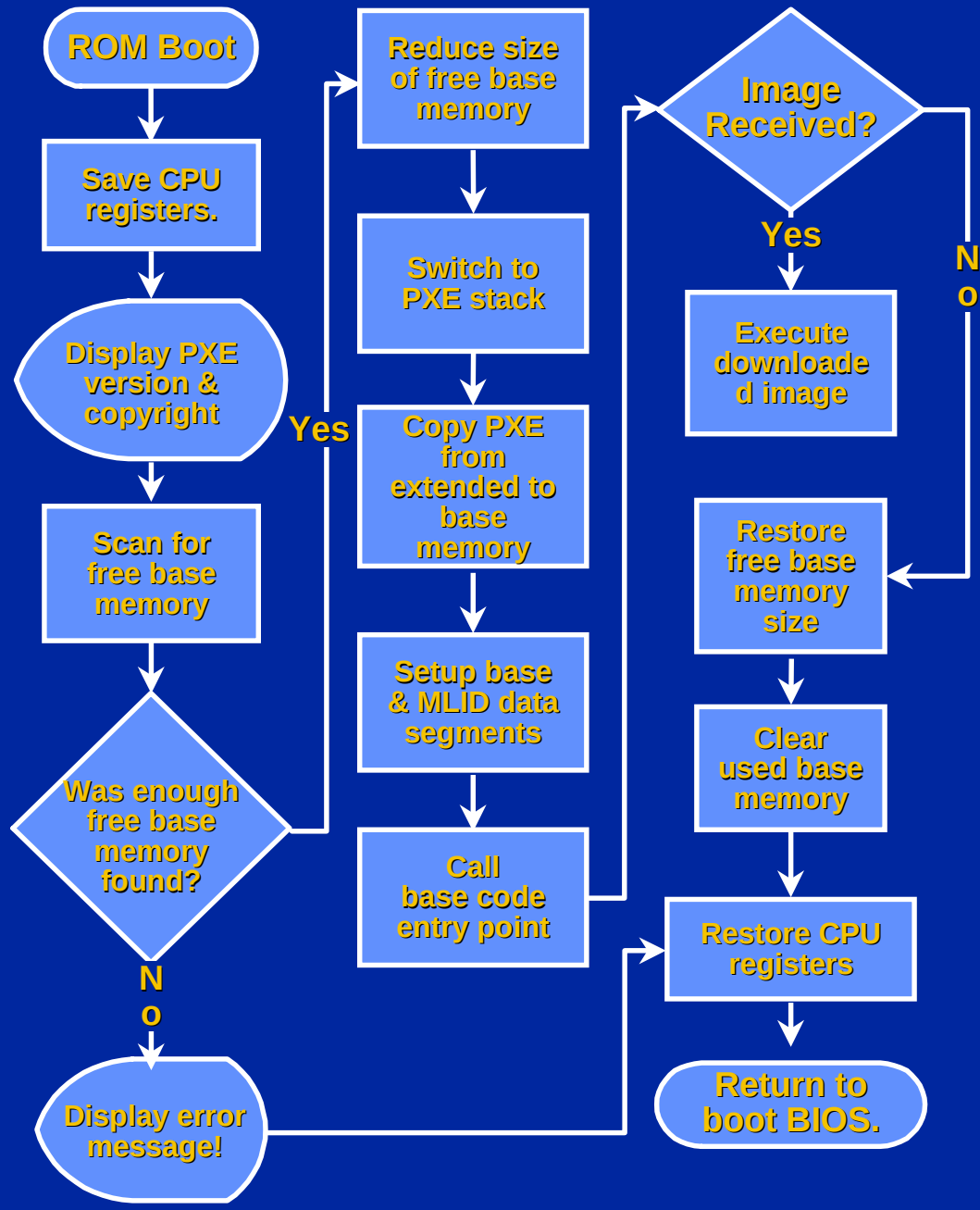
PXE Operation

- Initialization



PXE Operation

- Boot



Client State at Bootstrap Execution Time

- Bootstrap Calling Convention
  - CS:IP is to contain the value 0:7C00h
  - ES:BX is to contain the address of the PXENV Entry Point structure
  - EDX is to contain the physical address of the PXENV Entry Point structure
  - SS:SP is to contain the address of the beginning of the unused portion of the preboot services stack

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Client State at Bootstrap Execution Time

Address	Status	Preboot services usage	Conventional usage
7C00 10000		Downloaded Bootstrap	
10000 10000+SFBM-1		Free base memory	
10000+SFBM (SS:SP)		Preboot Services CPU Stack (unused)	
(SS:SP)+1 9FFFF	RESERVED	Preboot Services CPU Stack (used by Preboot Services) Preboot Services Code and Data Extended BIOS Data Area (possibly)	
A0000 DFFFF	RESERVED		
E0000 EFFFF	RESERVED	Contains a unique system ID structure.	Other BIOS / Upper Memory / System BIOS
F0000 FFFFF	RESERVED	Contains a unique system ID structure.	System BIOS

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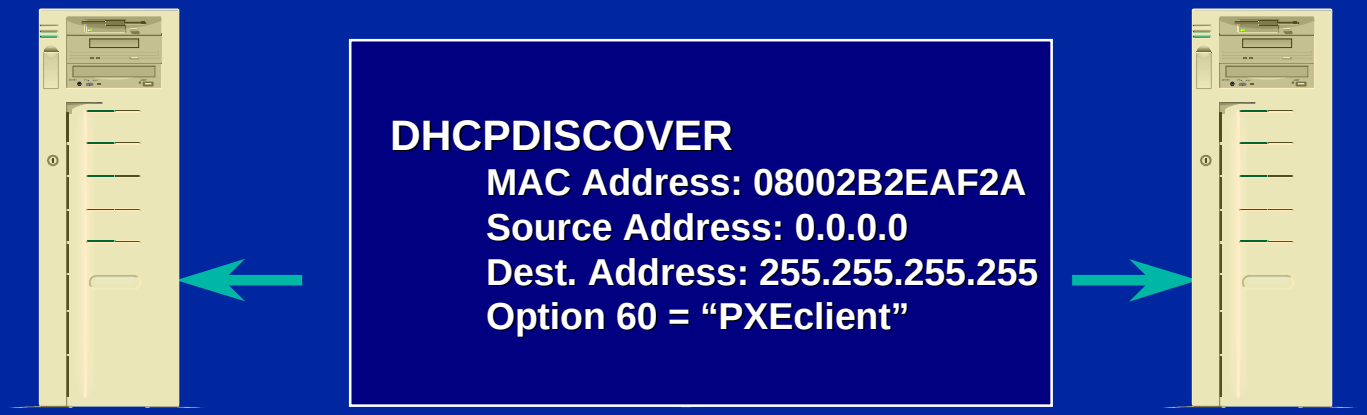
DHCP Overview

- Client Gets an Address
- Client Gets a Boot File
- Basic DHCP Packet

A Client Gets an Address



Serves NO addresses
proxyDHCP

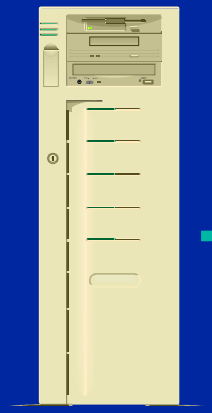
Serves addresses
132.200.50.101 through 200

Send DHCP Discover

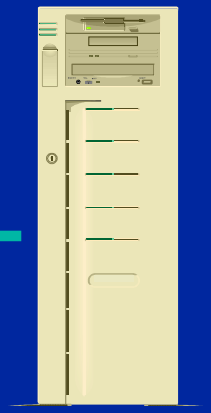
DHCP Messages

- **DHCPDISCOVER**
  - Initialization message from client
  - Broadcast
  - Client has no network address yet

A Client Gets an Address



Servers offer an address
DHCPOFFER



Serves NO addresses
proxyDHCP

Serves addresses
132.200.50.101 through 200

DHCPOFFER
MAC Address: 08002B2EAF2A
Source Address: 132.200.50.220
Dest. Address: 255.255.255.255
IP Address: 0.0.0.0
Subnet Mask: 255.255.255.0
Server Identifier: 132. 200.100.5
Option 60 = “PXEclient”

DHCPOFFER
MAC Address: 08002B2EAF2A
Source Address: 132.200.50.230
Dest. Address: 255.255.255.255
IP Address: 132.200.50.105
Subnet Mask: 255.255.255.0
Server Identifier: 132. 200.100.6
Lease Length: 504 Hours

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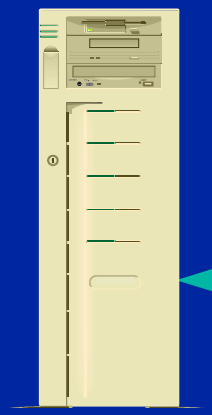
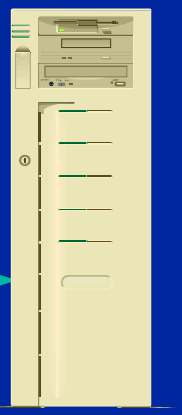
DHCP Messages

- DHCPDISCOVER
- DHCPOFFER
  - Each server offers an address
  - Address reserved in pool
  - Broadcast

A Client Gets an Address





DHCPREQUEST
MAC Address: 08002B2EAF2A
Source Address: 0.0.0.0
Dest. Address: 255.255.255.255
Req IP Address: 132.200.50.105
Server Identifier: 132.200.50.230
Requested Parameters: 3, 46...

132.200.50.105…
That's not mine.

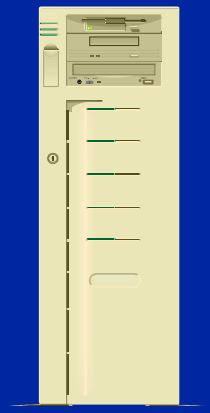
132.200.50.105…
Hey! That's mine!

Send DHCP Request

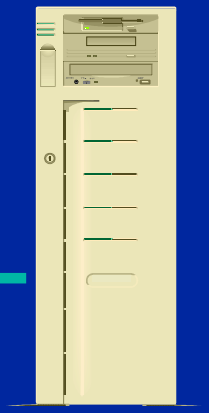
DHCP Messages

- DHCPDISCOVER
- DHCPOFFER
- DHCPREQUEST
  - Contains selected server, address
  - Broadcast - all servers receive
  - Declined server releases reservation
  - Contains request for configuration options

A Client Gets an Address



Server Sends DHCP ACK



DHCPACK

MAC Address: 08002B2EAF2A
Source Address: 132.200.50.230
Dest. Address: 255.255.255.255
IP Address: 132.200.50.105
Subnet Mask: 255.255.255.0
Server Identifier: 132. 200.100.6
Lease Length: 504 Hours
Requested Parameters: Gateway...

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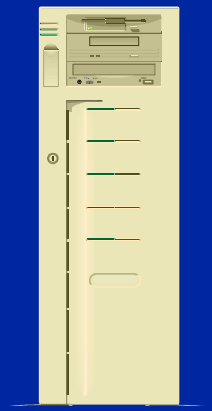
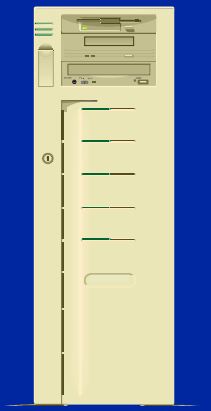
DHCP Messages

- DHCPDISCOVER
- DHCPOFFER
- DHCPREQUEST
- DHCPACK
  - Contains valid lease
  - Broadcast
  - Contains requested configuration options

A Client Gets an Address

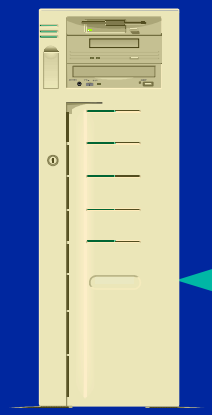


Client is now initialized
Ready to communicate!



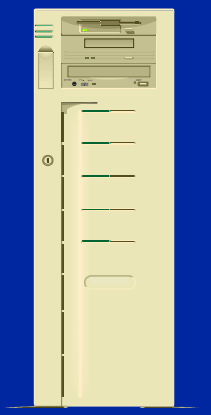
132.200.50.105

A Client Gets a Bootfile Name



DHCPREQUEST
MAC Address: 08002B2EAF2A
Source Address: 132.200.50.105
Dest. Address: 132.200.50.220

Requested Parameters: bootfile name...



132.200.50.105…
That's mine.

132.200.50.105…
Hey! I never saw that!!

Send DHCP Request

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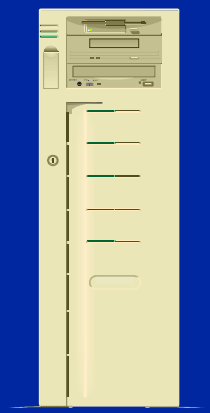
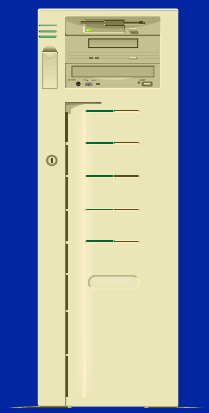
DHCP Messages

- **DHCPREQUEST**
  - Contains selected server, address
  - Unicast - only specific proxyDHCP server receives
  - Contains request for configuration options

A Client Gets a Bootfile Name



Send DHCP ACK



DHCPACK
MAC Address: 08002B2EAF2A
Source Address: 132.200.50.220
Dest. Address: 132.200.50.105
IP Address: 132.200.50.105
Requested Parameters: Bootfile name...

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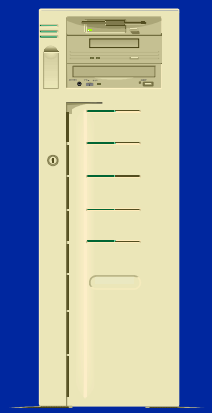
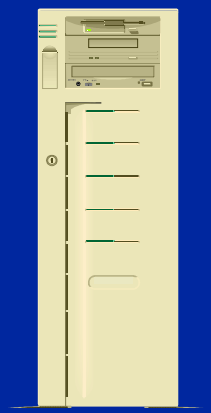
DHCP Messages

- DHCPREQUEST
- DHCPACK
  - Unicast
  - Contains requested configuration options

A Client Gets a Bootfile Name



Client is now initialized
Ready to download remote boot file via TFTP/MTFTP!



132.200.50.105

DHCP Packet Without Options

DHCP Header		
Field (length)	**Value**	**Comment**
op (1)	1,2,3, or 4	Code for DHCP packet type
htype (1)	*	
hlen (1)	*	
hops (1)	*	
xid (4)	*	
secs (2)	*	
flags (2)	*	
ciaddr (4)	0.0.0.0	PXE client always sets this value to 0.0.0.0
yiaddr (4)		Client's IP address. Provided by server
siaddr (4)	*	Next bootstrap server IP address
giaddr (4)	*	
chaddr (16)	xx-xx-xx-xx-xx-xx-xx-xx	Client's MAC address
sname (64)	*	
bootfile (128)	*	Network Bootstrap Program (NBP)

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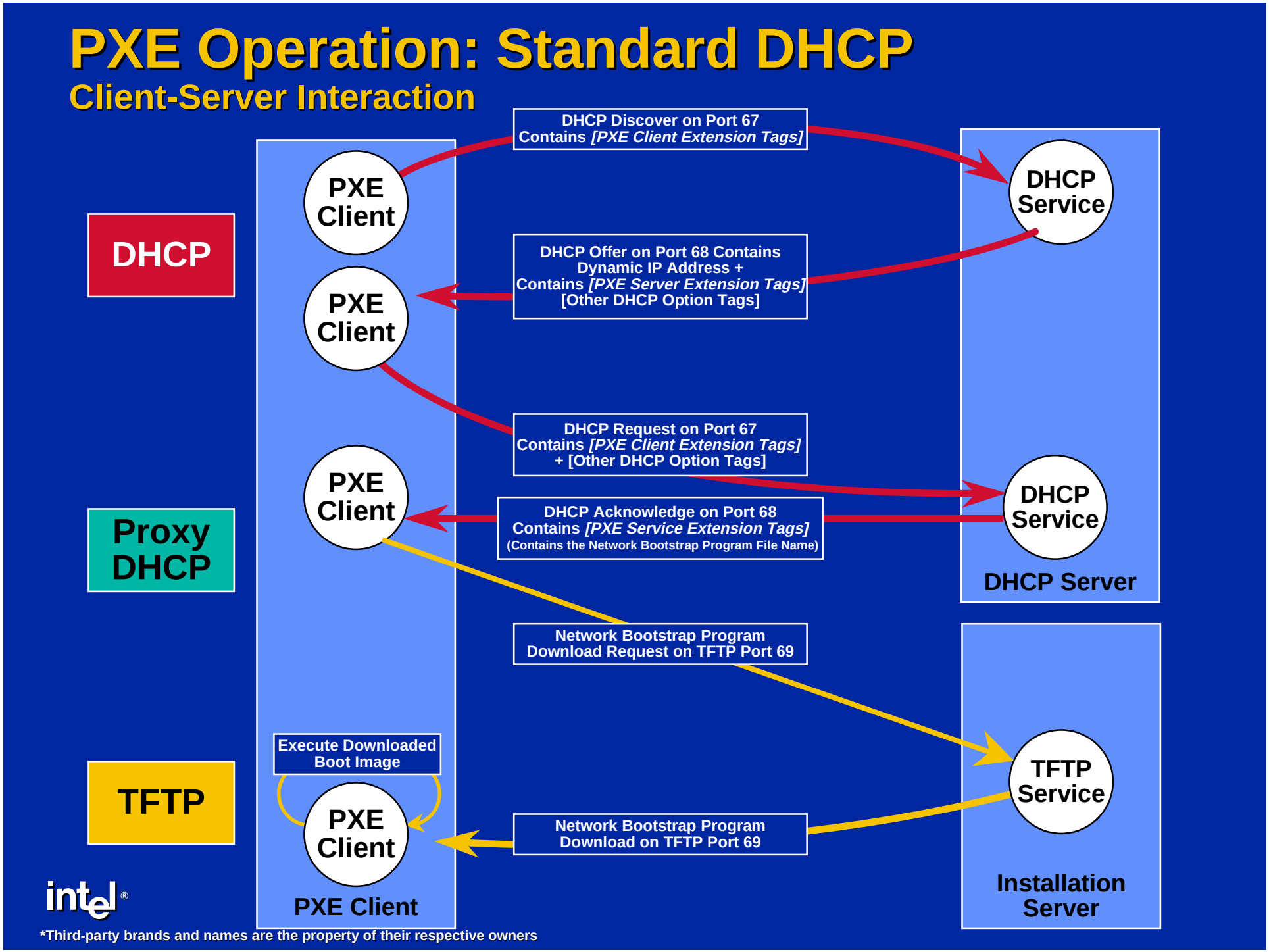
PXE DHCP Extensions

- Client Server Interaction
- PXE Client Redirection via DHCP
- DHCP Packet PXE Options

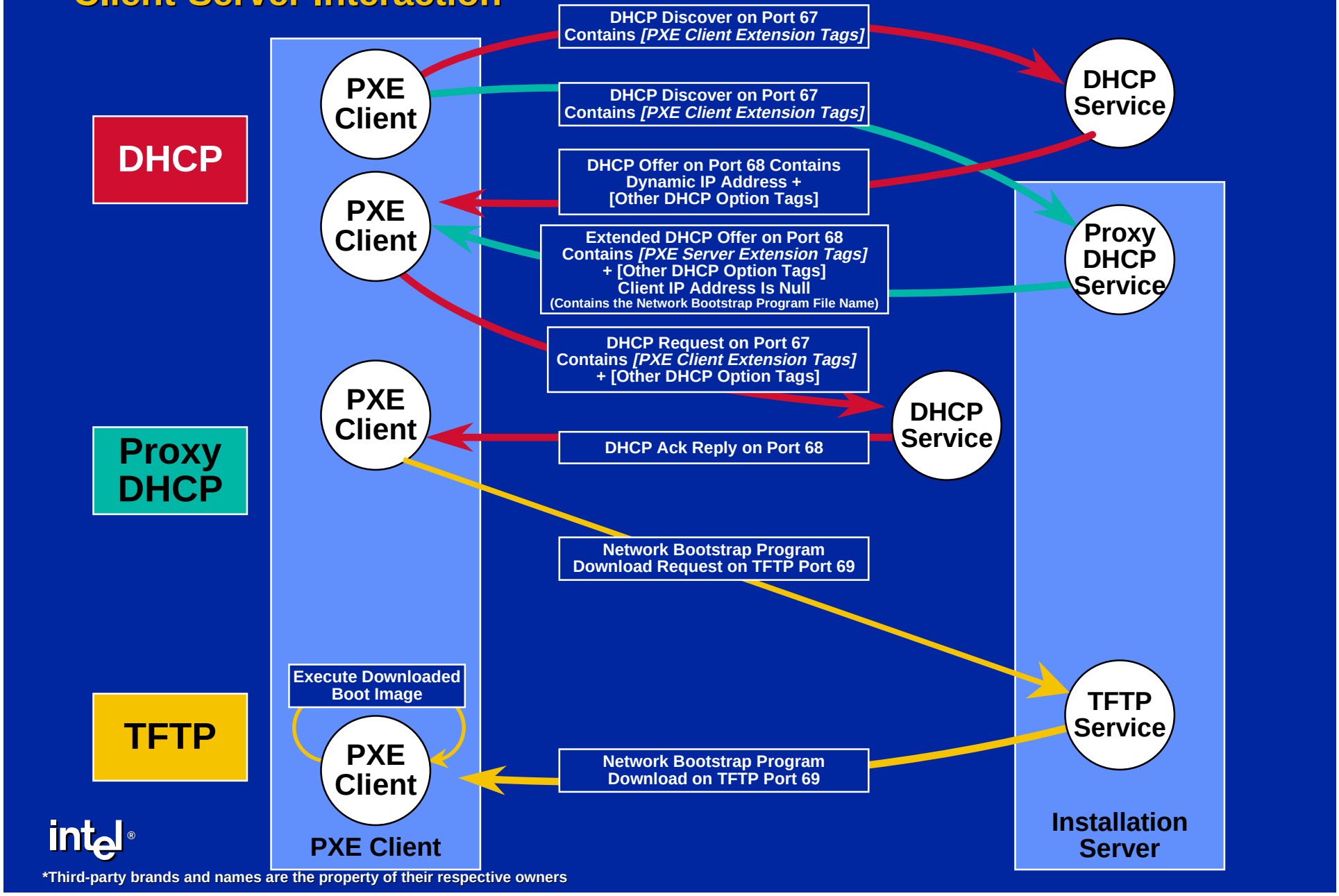
PXE Operation: Standard DHCP

Client-Server Interaction



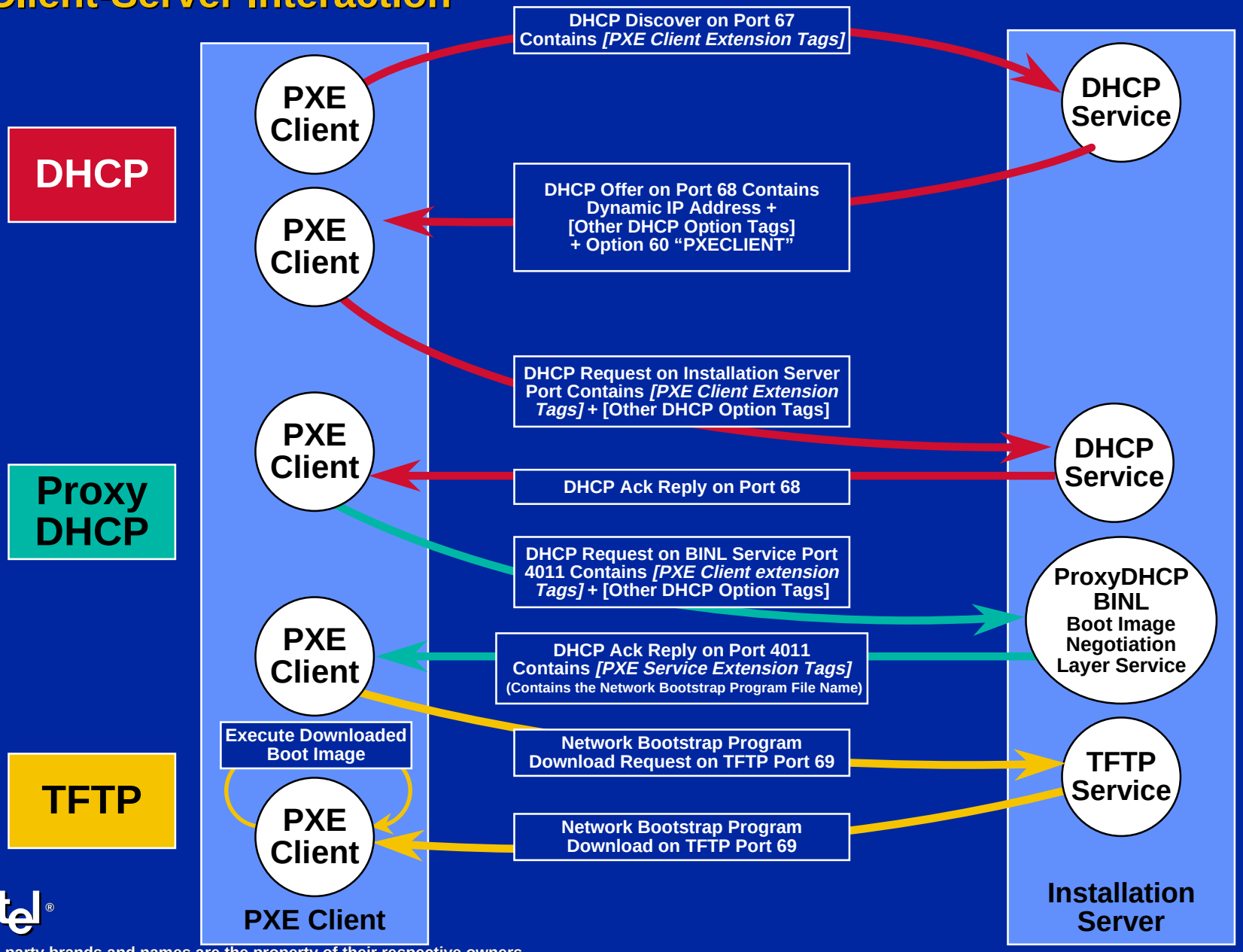
PXE Operation: Proxy on Install Server

Client-Server Interaction



PXE Operation: Proxy on DHCP Server

Client-Server Interaction



PXE Client Redirection Via DHCP

- IF DHCPOFFER
  - “bootfile” is null AND
  - Option 60 = “PXECLIENT”
- THEN redirect to BINL on UDP port 4011
- ELSE IF DHCPOFFER
  - “bootfile” is not null
- THEN use (M)TFTP to download “bootfile”

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DHCP Packet PXE Options

- Described in IETF Draft “DHCP Options For Host System Characteristics” (draft-dittert-host-sys-char-00.txt)
  - Option 60 - Class Identifier
    - “PXECLIENT”
  - Option 97 - UUID/GUID
  - Option 93 - Client System Architecture
    - Intel Architecture PC, NEC/PC98, etc.
  - Option 94 - Client Network Device Interface Type
    - UNDI
    - PCI
    - PNP

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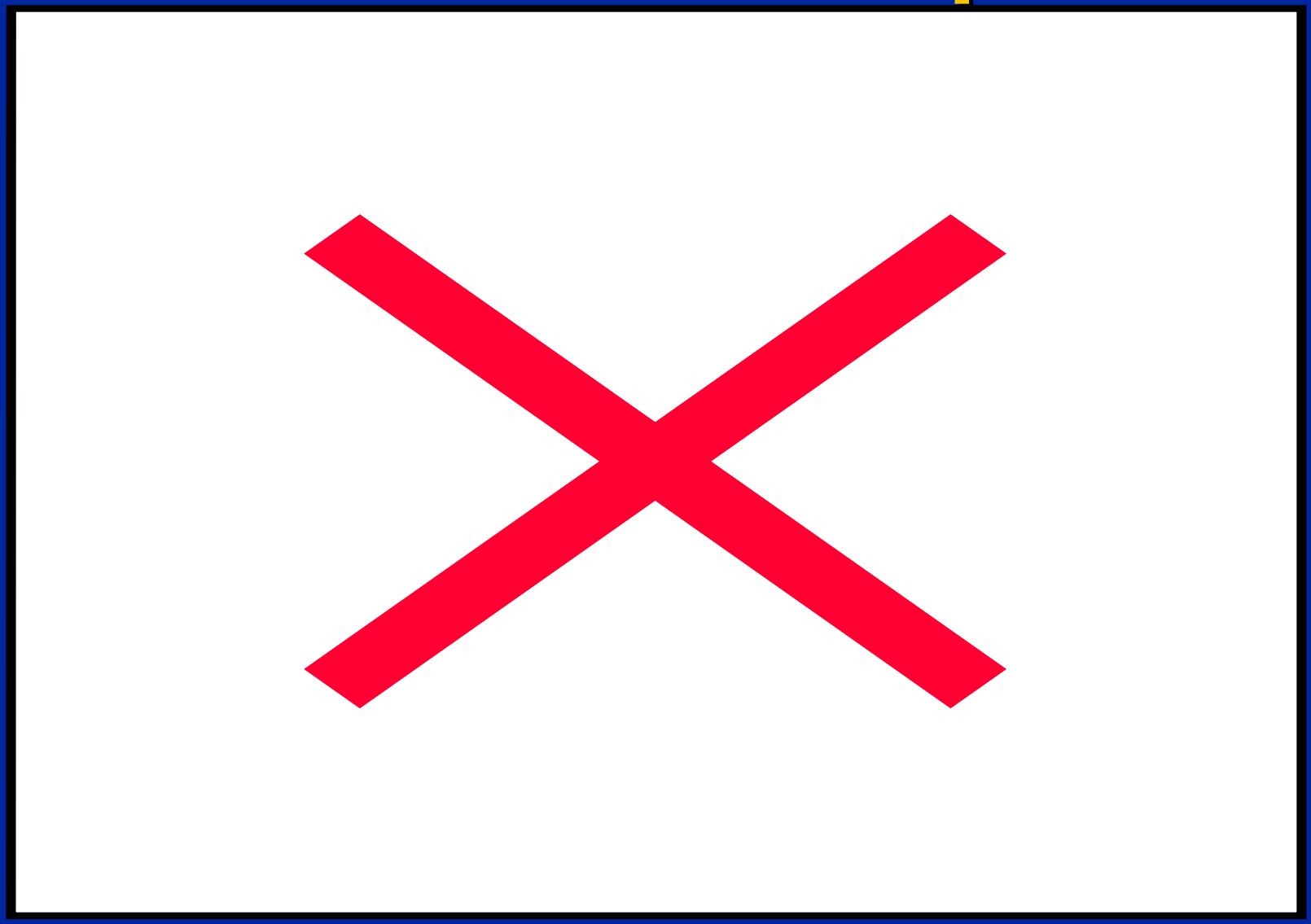
DHCP Packet PXE Options



DHCP Packet PXE Options

- Option 43 - Encapsulated Vendor Options
  - Tag #1 — MTFP IP Address
  - Tag #2 — MTFTP Client UDP port
  - Tag #3 — MTFTP Server UDP port
  - Tag #4 — MTFTP Start Delay
  - Tag #5 — MTFTP Timeout Delay
  - Tags 6-63 — Reserved
  - Tags 64-127 — Loader Options
  - Tags 128-254 — Vendor Options

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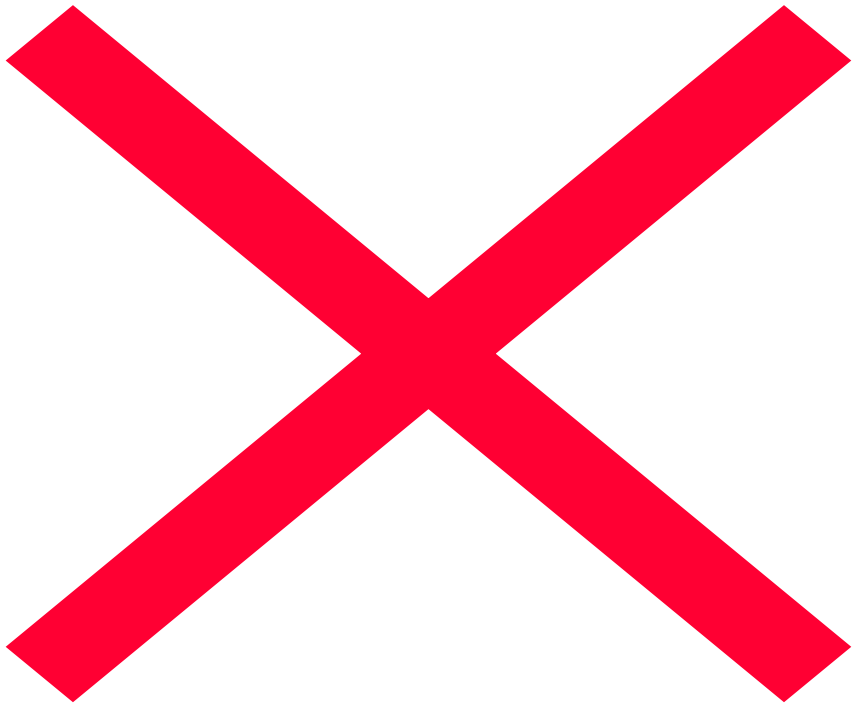

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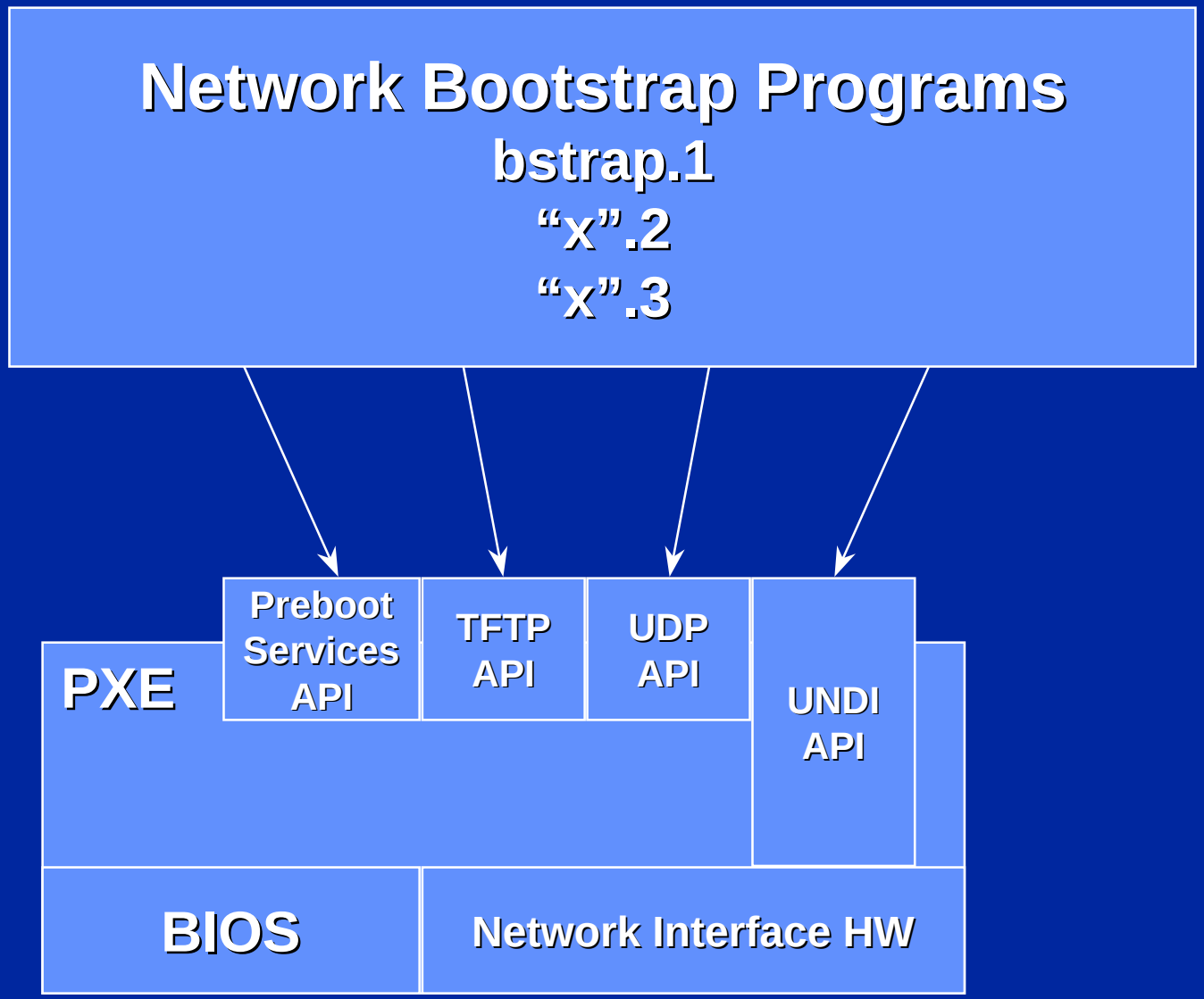
PXE APIs

- PXE API Stack
  - PREBOOT SERVICES
  - TFTP
  - UDP
  - UNDI

PXE API Stack



PXE APIs Provided to Network Bootstrap Programs

- PREBOOT SERVICES
- TFTP
- UDP
- UNDI

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PREBOOT SERVICES API

- Contains several global control and information functions
  - UNLOAD PREBOOT STACK
    - Removes PREBOOT SERVICES
  - GET BINL INFO
    - Provides copies of the DHCP packets(used for information passing from the DHCP layer to the Network Bootstrap Program)

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PREBOOT SERVICES API

- RESTART DHCP
  - Attempts to establish new DHCP connection
  - Downloaded file determined by server
- RESTART TFTP
  - Attempts to establish new TFTP connection
  - Downloaded file determined by client
- MODE SWITCH
  - Allows changing processor between real and protected modes

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TFTP API

- Loads the Network Bootstrap program and subsequent executables
  - TFTP OPEN
  - TFTP CLOSE
  - TFTP READ
  - TFTP/MTFTP READ FILE
  - PROTECTED MODE TFTP/ MTFTP READ FILE

UDP API

- Enables opening and closing UDP connections, and reading packets from and writing packets to a UDP connection
  - UDP Open
  - UDP Close
  - UDP Read
  - UDP Write

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UNDI API

- Enables basic control of the client's network interface device by the NBP
- Allows "universal" drivers (NDIS, Loaders, etc.) to be used in NBP

UNDI STARTUP
UNDI CLEANUP
UNDI INITIALIZE
UNDI RESET ADAPTER
UNDI SHUTDOWN
UNDI OPEN
UNDI CLOSE
UNDI TRANSMIT PACKET
UNDI GET NIC INFO

UNDI SET MULTICAST ADDR
UNDI GET MULTICAST ADDR
UNDI SET STATION ADDRESS
UNDI SET PACKET FILTER
UNDI GET INFORMATION
UNDI GET STATISTICS
UNDI CLEAR STATISTICS
UNDI INITIATE DIAGS
UNDI FORCE INTERRUPT

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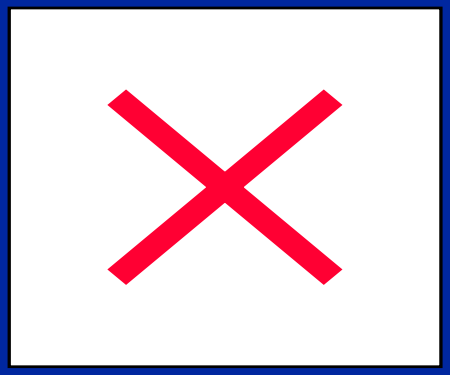
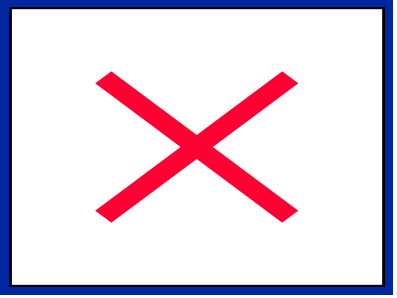
API Usage Example

UNDI NAPI (Child Version)



- Normal Sequence is as follows:
  {
  - Child - UNDI Transmit Packet
    /* UDP-Unreliable Delivery Proc */
  - Parent - UNDI Initiate Diags or
    UNDI Get Information /* Normally olfactory */
  - Parent - UNDI Open
  - Child (Possible) - UNDI Get Multicast Address
    - /*Care should be taken to handle this call properly while UNDI Open */
  - Parent - UNDI Cleanup /* NOT automatic */
  - Parent - UNDI Close
    }
- This procedure to be used until Child does:
  - UNDI Force Interrupt



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Agenda

- PXE Overview
- System Requirements
- PXE Basic Operation
- DHCP Overview
- PXE DHCP Extensions
- PXE APIs
- **Network Bootstrap Program**
- Product Development Kit

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Network Bootstrap Programs

- The “Remote Boot” executable downloaded via TFTP by PXE
- Uses the APIs provided by PXE
- NBPs are system specific and not specified by PXE

Network Bootstrap Programs

- "bstrap.0" (Universal "chooser")
  - Determines what is to be booted
  - Discovers associated bootserver
  - Loads "x.0" from discovered bootserver
- "x.0" (OS Loader)
  - Configures client and loads "x.2"
- "x.1" (Boot object)
  - (e.g. OS, application, etc.)

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NBP Example

LANDesk® Configuration Manager NBP Operation

- LCM uses three NBPs in series
  - bstrap.0
    - “Universal” bootstrap. Allows interoperability between “Management” and “OS” remote boot
    - MTFTPs man.0
  - man.0
    - Sets processor mode and operating environment
    - In LCM case, this means real mode and creation of virtual A: drive
    - MTFTPs man.1
  - man.1
    - “OS” executable
    - In LCM case, the “image file” containing DOS, CSAGENT, etc.

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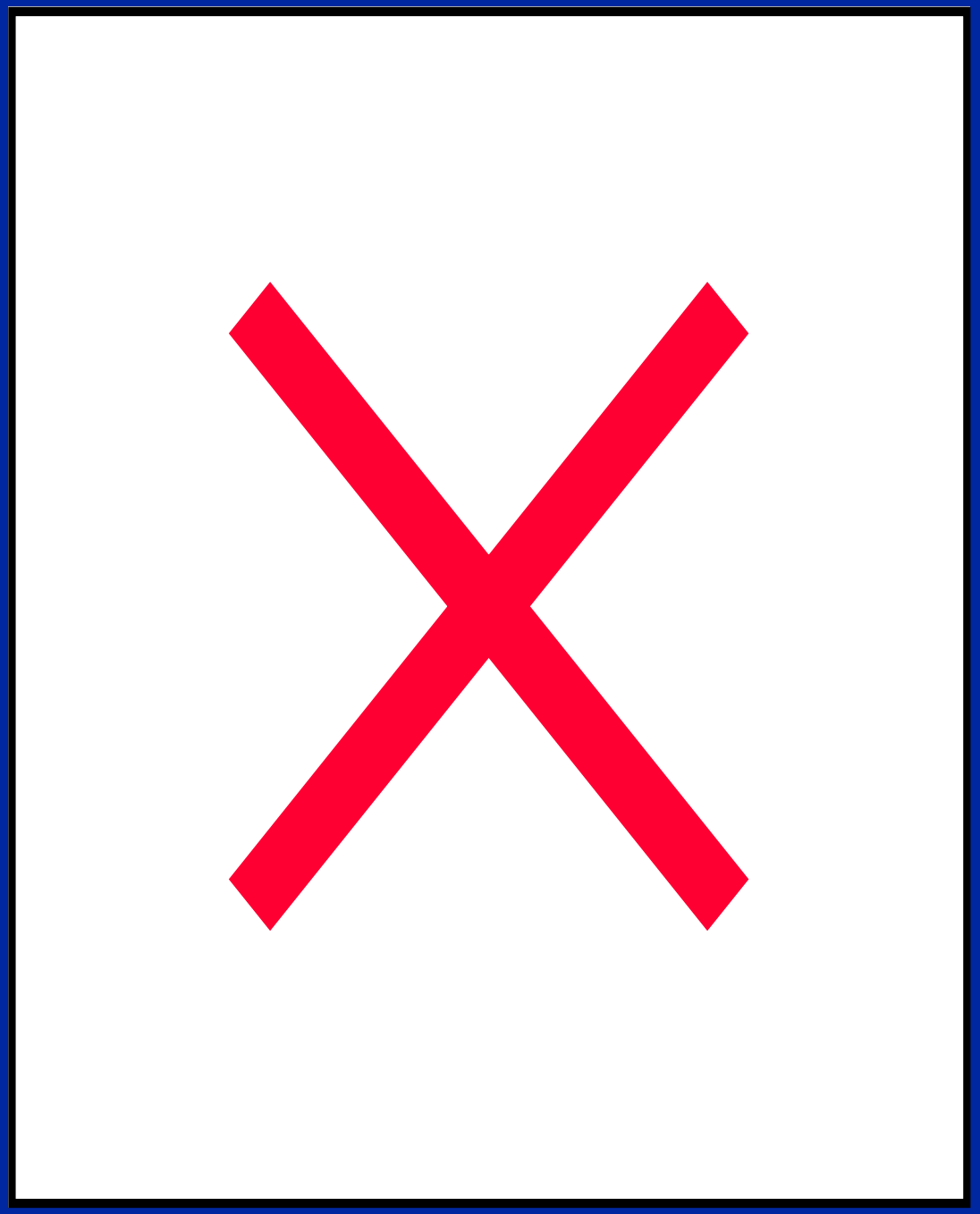
Bstrap.0

- Uses “Preboot Services” API
  - Determines “OS” options to present to user
- Resulting Menu:

<1> OS abc

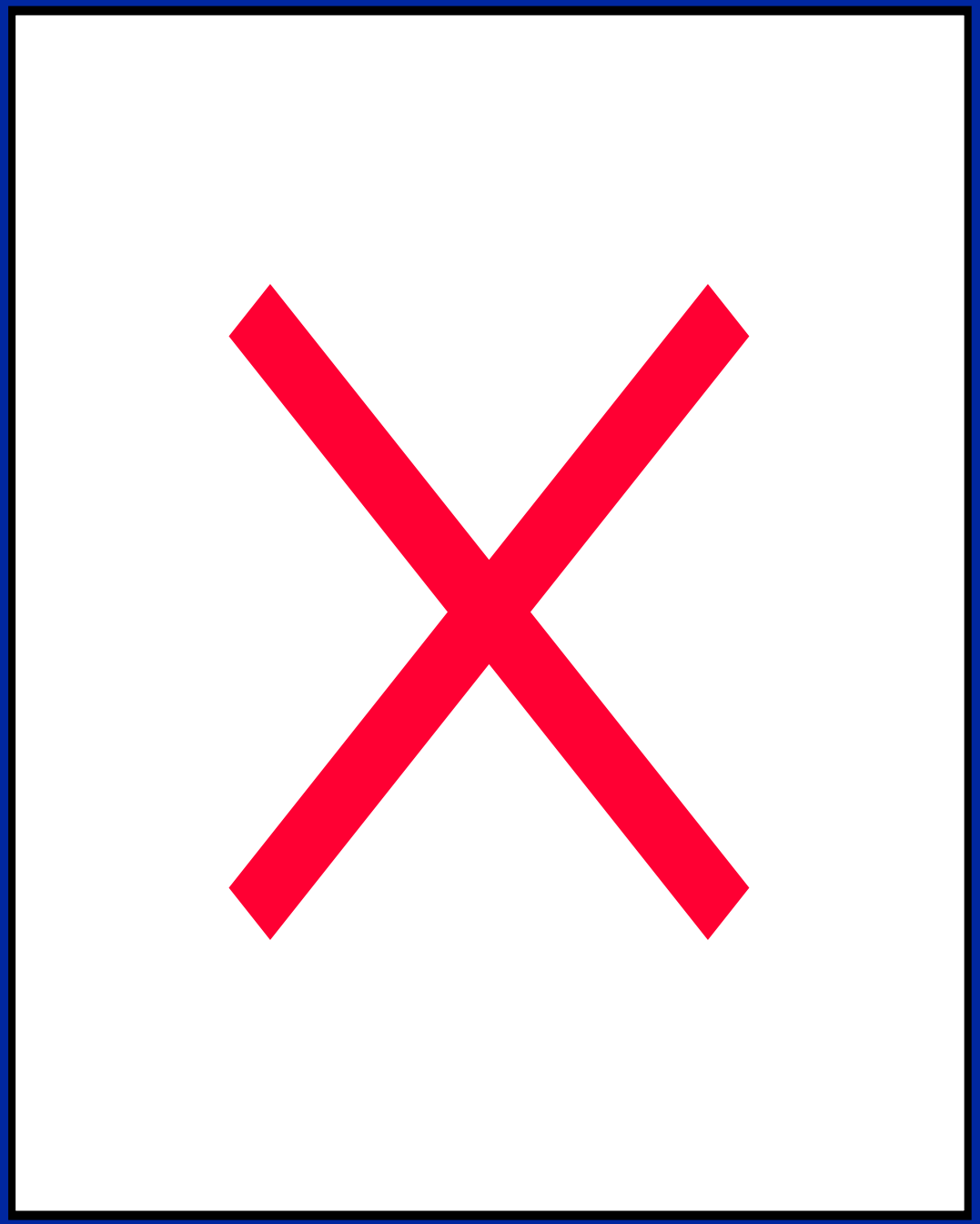
<2> Config Services

<3> OS xyz



man.1

- Uses “Preboot Services” API
  - Determines LCM specific info for CSAGENT which updates files in boot image:
    - system.ini
    - protocol.ini
    - lcm.cfg



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Product Development Kit

- Documentation
  - Setup Doc
  - PDK spec
  - Test Design Specification
- Windows NT Services (DHCP Support and Extensions)
  - proxyDHCP
  - BINL
  - TFTP

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Product Development Kit

- PXE Binary
  - Intel 82557/558 - NIC and BIOS version
  - Flash Utilities
- Network Bootstrap Programs
  - Basic bootstrap
    - bstrap.0
  - Execution Environment Setup Programs
    - test.0
    - dosundi.0
  - PXE API Test Programs
    - test.1
    - dosundi.1

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Product Development Kit

- PDK available via :
  - http://www.intel.com/ial/wfm/tools/pxe/index.htm

Call to Action

- Implement PXE
  - In all corporate desktop PCs
  - In all Network Interface Cards
- Support PXE in the BIOS
  - BIOS Boot Specification
  - SM BIOS

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Summary

- PXE Defines an Industry Standard Remote Boot Capability
- PXE Makes Systems Manageable "Out of the Box"
- PXE is Required By:
  - Wired for Management Baseline Specification
  - Network PC Design Guidelines
  - PC98 System Design Guide
- PXE Requires System BIOS Support
- PXE Uses New DHCP Functionality

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Collateral

- PXE PDK available via:
  - http://www.intel.com/ial/wfm/tools/pxe/index.htm
- Wired for Management Baseline Specification, Version 1.1a
  - http://www.intel.com/managedpc/spec.htm
- Net PC Design Guidelines, Version 1.0b
  - http://developer.intel.com/design/netpc/netovr.htm
- PC98 System Design Guide, Version 1.0
  - http://developer.intel.com/design/pc98/
- System Management BIOS
  - http://www.intel.com/managedpc/standard/smbios.htm
- BIOS Boot Specification Version 1.01
  - http://www.phoenix.com/techs/specs.html
- POST Memory Manager Specification, Version 1.0
  - http://www.phoenix.com/techs/specs.html
- Plug and Play BIOS Specification v. 1.0a
  - http://www.microsoft.com/hwdev/specs/pnpspecs.htm

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Background

A Word About LSA Versions

“LSA1”

- The Original LSA Implementation
  - Implemented Q4 1996
- Not Network PC Design Guidelines or WFM Compliant
  - Several “DHCP options” not per specification
  - Does not support UNDI API
  - Does not support GUID
  - Etc.

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“LSA2”

- Network PC Design Guidelines and WFM compliant
- Currently in Production
  - Available in the PXE PDK
- Will ship in:
  - LCMSA001, LCMSA002
  - Intel’s Network PC
  - All future Intel manufactured “LAN down” systems and motherboards

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LSA1 to LSA2 Upgrade

- LSA1 upgradable to LSA2 via:
  - BIOS “Flash” diskette
  - Landesk Configuration Manager service
- Landesk Configuration Manager Legacy Support for LSA1
  - LCM 1.5 supports LSA1 and LSA2
  - LCM 1.0 supports LSA1 only
  - LCM 1.0 does not support LSA2

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