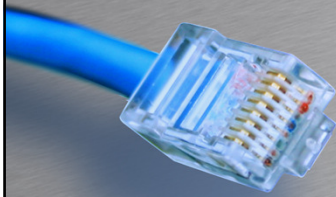


# IP version 6



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## Kapitel 3: IPv6 in Depth

**Baseret på bogen:** Cisco Self-study: Implementing Cisco IPv6 Networks

Henrik Thomsen V1.0




## Indhold

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- ICMPv6
- Neighbor Discovery Protocol
- Stateless Autoconfiguration




## ICMPv6

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- Internet Control Message Protocol for IPv6
- Beskrevet i [rfc2463](#) obsoleted af [rfc4443](#)
  - [rfc4443](#) er opteret af [rfc4884](#)
- ICMPv6 rapporterer fejl og information til Source-Noden om overførsel af trafik til Destination-Noden.
- ICMPv6 er protokol 58 (IANA)
  - Next-Header=58
- Bygger på ICMPv4 protokollen



## ICMPv6


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- ICMP type – Hvilken slags ICMP (fx Ping)
- ICMP code – Detaljeret information om type
- Checksum – Dækker hele ICMP pakken

Version	Traffic Class	Flow Label	
Payload Length		Next Header=58	Hop Limit
Source IP address			
Destination IP address			
ICMPv6 type	ICMPv6 code	Checksum	
ICMPv6 data			




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## ICMPv6 type eksempler

Message	Type	Type of Message	Definition
Destination Unreachable	1	Error	The IP address or port is not active in the destination host.
Packet Too Big	2	Error	The packet is larger than the MTU of the outgoing link.
Time Exceeded	3	Error	Hop-Limit reached 0, the packet is discarded, and an intermediary router notifies the source.
Echo Request	128	Informational	A message sent to a destination to request a reply message.
Echo Reply	129	Informational	A message used as response to the Echo Request message.

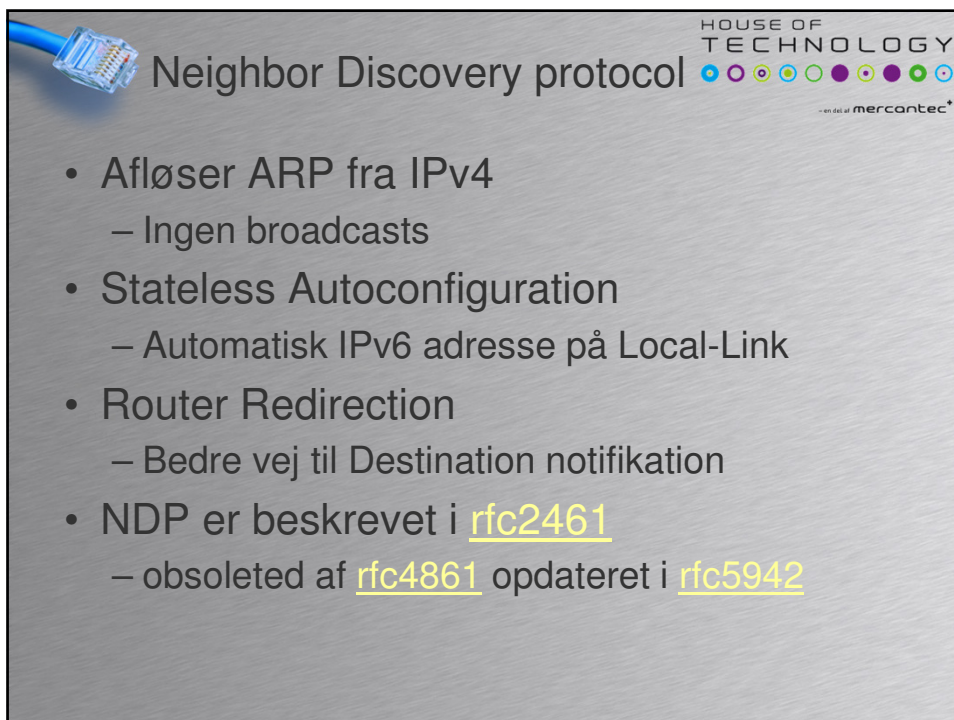
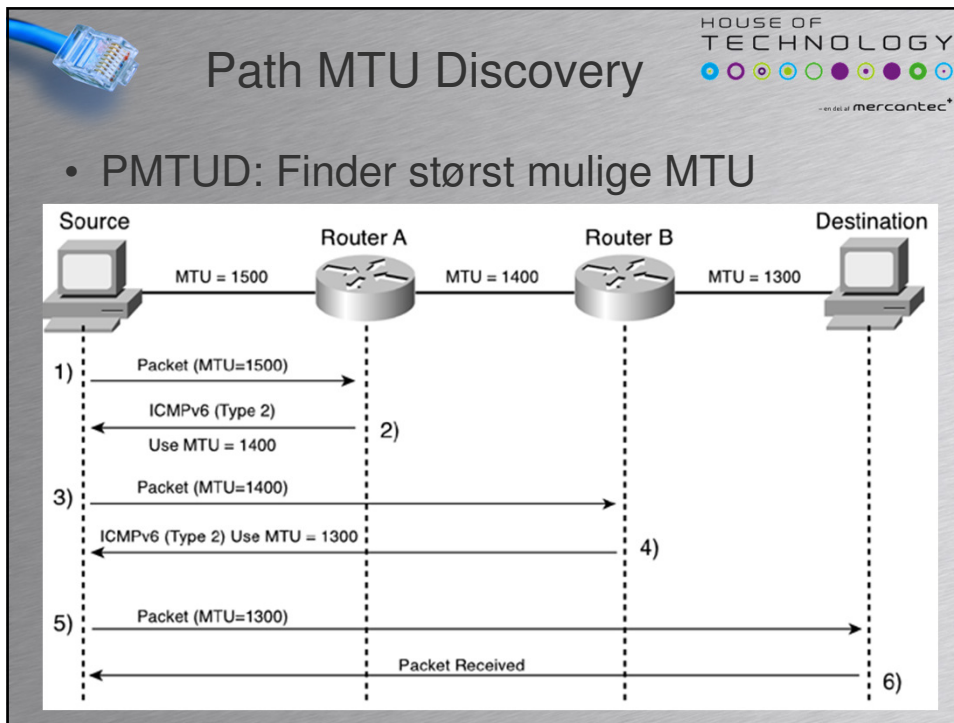
ICMPv6 type	ICMPv6 code	Checksum
ICMPv6 data		



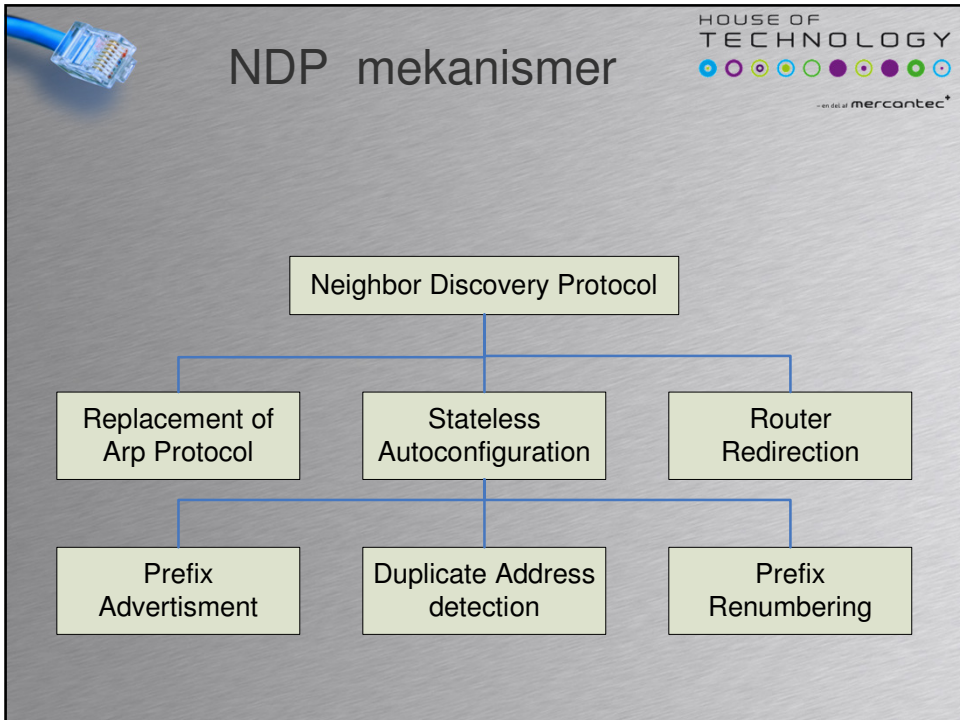
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## ICMPv6 typer

- Afløsning af ARP protokollen
  - En del af NDP – Neighbor Discovery Protocol
- Stateless Autoconfiguration
  - Konfigurerer automatisk IPv6 adresse
- Duplicate Address detection (DAD)
  - Verificerer om IPv6 adresse er i brug
- Prefix Renumbering
  - Automatisk ændring af Prefix – in flight
- Path MTU Discovery
  - Find største MTU til en given destination







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ICMPv6 Type	Name of Message
Type 133	Router solicitation (RS)
Type 134	Router advertisement (RA)
Type 135	Neighbor solicitation (NS)
Type 136	Neighbor advertisement (NA)
Type 137	Redirect message

Mechanism	Type 133	Type 134	Type 135	Type 136	Type 137
Replacement of ARP			X	X	
Prefix advertisement	X	X			
Prefix renumbering	X	X			
DAD			X		
Router redirection					X

ICMPv6 type	ICMPv6 code	Checksum
ICMPv6 data		




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## Neighbor Discovery Table

- IPv6 adresse til Link-Layer (MAC adresse)
  - Som ARP tabel

mars.tekkom.dk - PuTTY


```
Campus1#show ipv6 neighbors
IPv6 Address                               Age Link-layer Addr
FE80::216:76FF:FE9F:FEF6                   31 0016.769f.fef6
FE80::9284:DFF:FE5D:DCA2                   0 9084.0d5d.dca2
FE80::9221:55FF:FEBD:B2EB                   31 9021.55bd.b2eb
FE80::128C:CFFF:FE96:F76F                   0 108c.cf96.f76f
2001:16D8:DD85:139:9DAC:27C8:B159:1755    32 0024.d717.2b40
FE80::25BE:CA0A:FC9B:73A1                   10 000c.2982.6bc8
2001:16D8:DD85:139:20C:29FF:FE36:45B1    32 000c.2936.45b1
FE80::385E:C561:FCF9:7D57                   6 0050.568b.0004
FE80::129A:DFFF:FE1E:ECEF                   12 109a.dd1e.ecef
```




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## NDP

- Fungerer som ARP bortset fra der ikke Broadcastes men Multicastes
  - Der sendes en Request pakke. (Find MAC)
  - Der returneres en Response pakke



MAC: 00:10:E3:88:A8:67  
IP: 2001:6D8:DD85:4::44



MAC: 00:10:11:34:54:0A  
IP: 2001:6D8:DD85:4::99


Local Link

Command Prompt

```
1 C:\>ping 2001:6D8:DD85:4:99
```


2 ————— Multicast pakke sendes - Hvad er din MAC? —————>

3 <————— Unicast pakke returneres - 00:10:11:34:54:0A —————



## NDP multicast

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- Solicited-Node Multicast på OSI lag 3
  - Solicited betyder – Anmodet
- Syntax: FF02::1:FFxx:yyzz
  - xx:yy:zz er sidste 24 bit i IP adresse


128 bit IP adresse

2001	16D8	DD85	0139	0221	86FF	FEA0	6E84
------	------	------	------	------	------	------	------

128 bit Solicited Node Multicast adresse


FF02	0000	0000	0000	0000	0001	FFA0	6E84
------	------	------	------	------	------	------	------

24 bit



## NDP multicast

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- På Ethernet anvendes 33:33:xx:yy:zz:ww som Layer 2 multicast ([rfc2464](http://rfc2464))
  - xx:yy:zz:ww erstattes med sidste 32 bit i IPv6 Solicited Multicast adresse

128 bit IP adresse

FF02	0000	0000	0000	0000	0001	FFA0	6E84
------	------	------	------	------	------	------	------

IPv6 Multicast adresse til Ethernet multicast adresse


33	33	FFA0	6E84
----	----	------	------

48 bit MAC



# Link-Layer multicast

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```

Administrator: Command Prompt
C:\Windows\system32>NETSH inter ipv6 show nei 12

Interface 12: Local Area Connection

Internet Address                Physical Address
-----
ff02::2                        33-33-00-00-00-02
ff02::16                       33-33-00-00-00-16
ff02::1:2                      33-33-00-01-00-02
ff02::1:3                      33-33-00-01-00-03
ff02::1:ffa0:ce84              33-33-ff-a0-ce-84
  
```

# IPv6 Address Mapping - 1

– En Node med ukendt Mac-adresse pinges


- ICMP type 135: Neighbor Solicitation

```

IP          : 2001:6D8:DD85:4::1:44
Multicast  : FF02::1:FF01:44
MAC        : 00:10:E3:88:A8:67
Multicast MAC: 33:33:FF:01:00:44
  
```

```

IP          : 2001:6D8:DD85:4::2:99
Multicast IP : FF02::1:FF02:99
MAC        : 00:10:11:34:54:0A
Multicast MAC: 33:33:FF:02:00:99
  
```



Local Link

Ttl-MAC: 33:33:FF:02:00:99		Fra-MAC: 00:10:E3:88:A8:67		Type: 86DD	Ethernet
ver	Traffic Class	Flow Label			
Payload Length		Protocol=58		Hop Limit	IPv6
Source Address = 2001:6D8:DD85:4::1:44				Destination Address = FF02::1:FF02:0099	
Type=135	Code=0	Checksum		ICMPv6	
Target Address = 2001:6D8:DD85:4::2:99					



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## IPv6 Address Mapping - 2

– Node med ukendt adresse svarer tilbage

- ICMP type 136: Neighbor Advertisement

IP : 2001:6D8:DD85:4::1:44      IP : 2001:6D8:DD85:4::2:99  
 Multicast : FF02::1:FF01:44      Multicast IP : FF02::1:FF02:99  
 MAC : 00:10:E3:88:A8:67      MAC : 00:10:11:34:54:0A  
 Multicast MAC: 33:33:FF:01:00:44      Multicast MAC: 33:33:FF:02:00:99

Command Prompt  
 C:\>ping 2001:6D8:DD85:4::2:99


Local Link

Til-MAC: 00:10:E3:88:A8:67	Fra-MAC: 00:10:11:34:54:0A	Type: 86DD	Ethernet
ver	Traffic Class	Flow Label	
Payload Length		Protocol=58	IPv6
Source Address = 2001:6D8:DD85:4::2:99		Hop Limit	
Destination Address = 2001:6D8:DD85:4::1:44			ICMPv6
Type=136	Code=0	Checksum	
Link-Layer address = 00:10:11:34:54:0A			

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## Definitioner


IP Enhed	Forklaring
<b>Node</b>	En enhed der har IP (Gælder både IPv4 og IPv6)
<b>Router</b>	En Node som videresender trafik som ikke er adresseret til den
<b>Host</b>	En Node som ikke er en Router



## Konfiguration af Hosts

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- Stateless Autoconfiguration
  - Hosts får Prefix fra Link-local Router
  - Finder egen EUI-64 eller Random Interface ID
  - Bruger Router som Default-Gateway
- Statefull Autoconfiguration
  - Hosts får konfiguration fra DHCPv6 server
- Stateless og Statefull
  - IP adresse og Gateway fra Stateless
  - DNS servere fra Statefull



## Konfiguration af Hosts

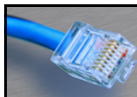
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- Dualstack implementering
  - Hosts får DNS fra DHCPv4 server
- Stateless Autokonfiguration af IPv6



## Stateless Autokonfig


- Nodes autokonfigurerer egen IPv6 adresse
- Stateless autoconfiguration består af
  - Prefix Advertisement
    - Røutere annoncerer prefixer pÅ link
    - RA – Router Advertisement ICMPv6 type 134
  - Duplicate Address Detection
    - Sikrer unikke IPv6 adresser pÅ Link
    - NS – Neighbor Solicitation ICMPv6 type 135
  - Prefix Renumbering
    - Ændrede eller nye Prefixer annonceres af Røutere
    - RA – Router Advertisement ICMPv6 type 134



## Router Advertisements

- Annoncerer Link-Lokale prefixes periodisk
  - Cisco default hver 200. sekund
- Indeholder
  - Prefix (Fx. 2001:67:E2::/64)
  - MTU (1500 byte)
  - MAC pÅ default Gateway (00:10:FE:10:11:A1)
- Nodes autokonfigurerer IP baseret pÅ EUI-64
  - Windows 7 vÆlger default tilfÆldig Interface ID
- Beskrevet i [rfc2462](#) obsoleted af [rfc4862](#)






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## Router Advertisements

- 200 sekunder er lang tid
- Node sender "Router Solicitation Message"
  - ICMPv6 type 133
  - Max. Tre "RS messages" må sendes. (Flooding)
- Router sender "Router Advertisement" straks.
  - ICMPv6 type 134
- Fang med Wireshark

Administrator: Command Prompt

```
C:\>ipconfig/renew6
```



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## Router Solicitation

IP : 2001:6D8:DD85:4::1:44/64

Link Local IP: FE80::0210:E3FF:FE88:A867

Multicast : FF02::1:FF01:44

MAC : 00:10:E3:88:A8:67

Multicast MAC: 33:33:FF:01:00:44



?

FE80::0210:11FF:FE34:540A

FF02::1:FF02:99

00:10:11:34:54:0A

33:33:FF:02:00:99

Local Link

Ttl-MAC: 33:33:00:00:00:02		Fra-MAC: 00:10:11:34:54:0A		Type: 86DD
ver	Traffic Class	Flow Label		
Payload Length		Protocol=58	Hop Limit	
Source Address = FE80::0210:11FF:FE34:540A				
Destination Address = FF02::2				
Type=133	Code=0	Checksum		
Link-Layer address = 00:10:11:34:54:0A				

} Ethernet

} IPv6

} ICMPv6



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## Router Advertisement

IP : 2001:6D8:DD85:4::1:44/64      ?  
 Link Local IP: FE80::0210:E3FF:FE88:A867      FE80::0210:11FF:FE34:540A  
 Multicast : FF02::1:FF01:44      FF02::1:FF02:99  
 MAC : 00:10:E3:88:A8:67      00:10:11:34:54:0A  
 Multicast MAC: 33:33:FF:01:00:44      33:33:FF:02:00:99

Ttl-MAC: 33:33:00:00:00:01		Fra-MAC: 00:10:E3:88:A8:67		Type: 86DD
ver	Traffic Class	Flow Label		
Payload Length		Protocol=58	Hop Limit	
Source Address = FE80::0210:E3FF:FE88:A867				
Destination Address = FF02::1 - (Link Local - All nodes)				
Type=134	Code=0	Checksum		
Link Layer = 00:10:E3:88:A8:67				
MTU = 1500 Bytes				
Prefix = 2001:6d8:DD85:4/64				

Local Link

Ethernet  
IPv6  
ICMPv6

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## RA – Node finder IP

IP : 2001:6D8:DD85:4::1:44/64      2001:6D8:DD85:4:0210:11:FF:FE34:540A  
 Link Local IP: FE80::0210:E3FF:FE88:A867      FE80:0210:11FF:FE34:540A  
 Multicast : FF02::1:FF01:44      FF02::1:FF02:99  
 MAC : 00:10:E3:88:A8:67      00:10:11:34:54:0A  
 Multicast MAC: 33:33:FF:01:00:44      33:33:FF:02:00:99

Local Link

- Router Advertisement indeholder også
  - Prefix information levetid
    - Cisco default Valid Lifetime = 2.592.000 sekunder
    - 30 dage

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## Router Advertisement

- Slå RA fra på uønskede Interfaces

The diagram illustrates a network topology where three routers are connected to a central cloud labeled 'Internet'. Each router is marked with a red 'X' over its top surface, signifying that Router Advertisement (RA) is disabled on these interfaces. The routers are interconnected in a mesh-like structure, with one router at the bottom connected to the Internet cloud.

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## Duplicate Address Detection

- Duplicate Address Detection eller DAD
- Før en autokonfigureret IP bliver aktiv
  - Sendes en "Neighbor Solicitation Message"
    - ICMPv6 type 135 multicast besked
- IP adressen :: anvendes som afsender
  - :: kaldes Unspecified Address
- Hvis ingen svarer på beskeden
  - IP adressen anvendes på Interfacet

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## Duplicate Address Detection

IP : 2001:6D8:DD85:4:0210:11FF:FE:34:54:0A  
 Link Local IP: FE80::0210:11FF:FE34:540A  
 Multicast : FF02::1:FF34:54:0A  
 MAC : 00:10:11:34:54:0A  
 Multicast MAC: 33:33:FF:34:54:0A

Andre noder

Local Link


Ti-MAC: 33:33:FF:34:54:0A		Fra-MAC: 00:10:11:34:54:0A		Type: 86DD	Ethernet	
ver	Traffic Class	Flow Label				
Payload Length		Protocol=58		Hop Limit	IPv6	
Source Address = ::						
Destination Address = FF02::1:FF34:54:0A						
Type=135	Code=0		Checksum			ICMPv6
Target = 2001:6D8:DD85:4:0210:11FF:FE:34:54:0A						

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## Prefix Renumbering

- Hvor kommer DNS og andre oplysninger fra?????
- Stateless vs. Statefull /combination?






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## Prefix Renumbering

- Skift af Prefix i IPv6
  - Både den nye og gamle Prefix annonceres
  - Senere fjernes den gamle Prefix
  - Alle bruger den nye

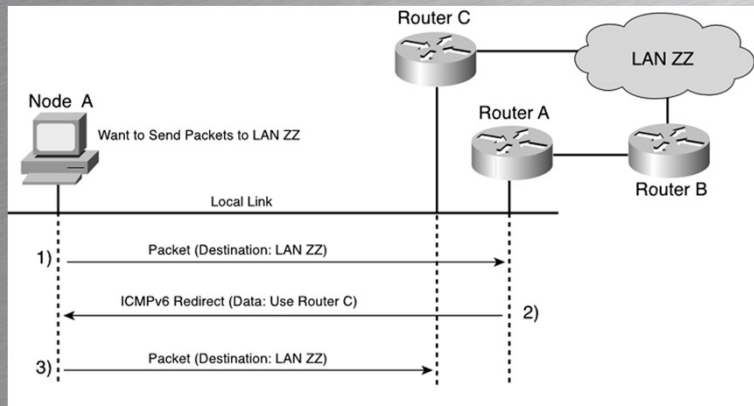
```
interface FastEthernet0/0
description Inside - Advertise new prefix 21:26::1/64 recommission
ipv6 address 21:26::1/64
ipv6 address 2001:1::/64 eui-64
ipv6 nd prefix 2001:1::/64 at 12 Dec 2011 03:00 12 Dec 2011 02:59
ipv6 nd ra interval 60
```



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## Router Redirection


- NDP procedure ICMPv6 Type=137
- Routers adviserer Nodes om bedre vej



The diagram illustrates the ICMPv6 Redirect procedure. Node A, which wants to send packets to LAN ZZ, initially sends a packet (1) to Router A. Router A then sends an ICMPv6 Redirect message (2) back to Node A, advising it to use Router C as a better path. Finally, Node A sends the packet (3) directly to Router C, which is connected to LAN ZZ.

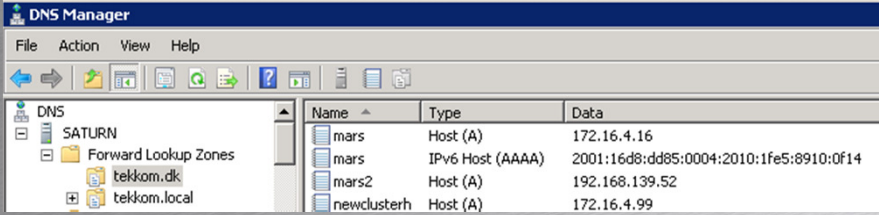


# DNS




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Protocol	Record	FQDN	Adresse
IPv4	A	mars.tekkom.dk	83.90.47.30
IPv6	AAAA	mars.tekkom.dk	2001:16D8:DD85:4:2010:1FE5:8910:F14



# Reverse DNS



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Protocol	Record	FQDN	Adresse
IPv4	A	mars.tekkom.dk	83.90.47.30
IPv6	AAAA	mars.tekkom.dk	2001:16D8:DD85:4:2010:1FE5:8910:F14

