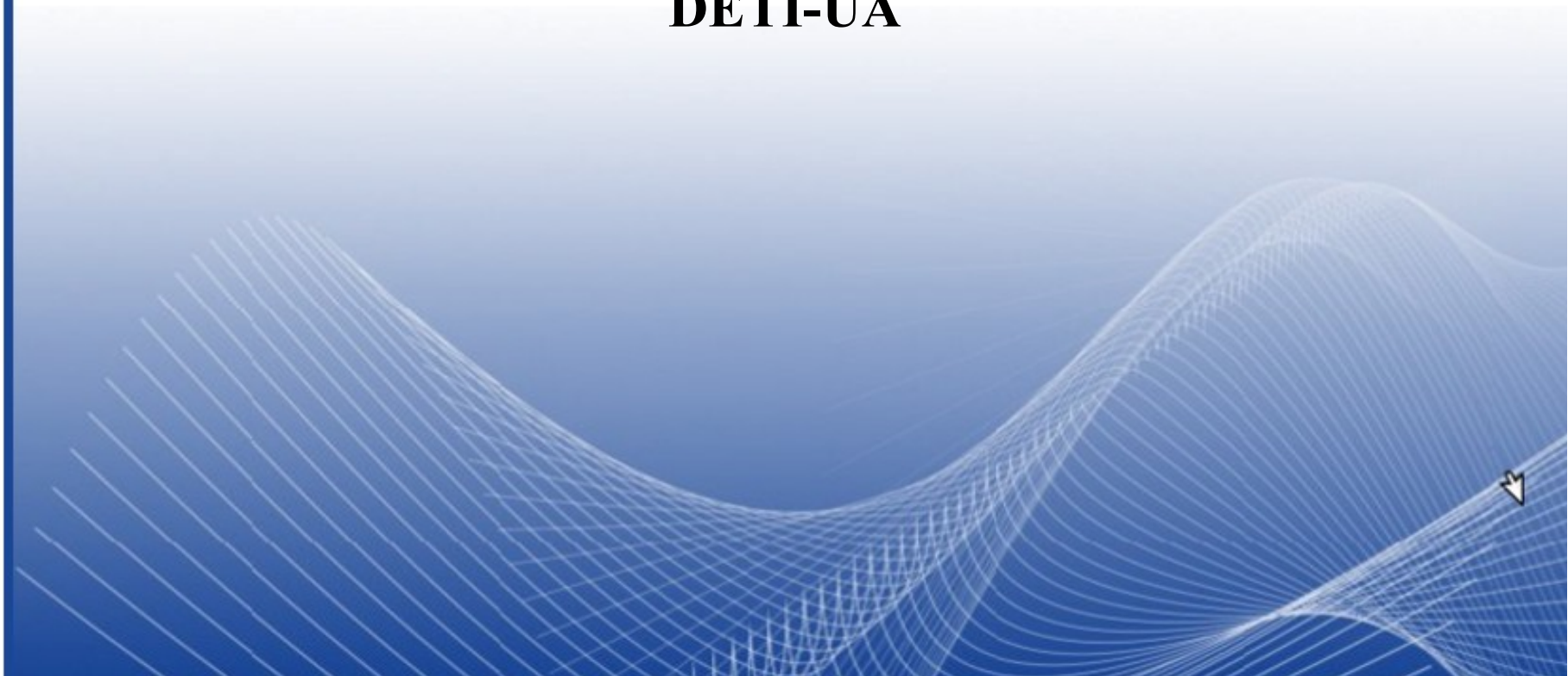
Camada de Rede (Protocolos de Suporte)

Redes e Serviços

Licenciatura em Engenharia Informática
DETI-UA



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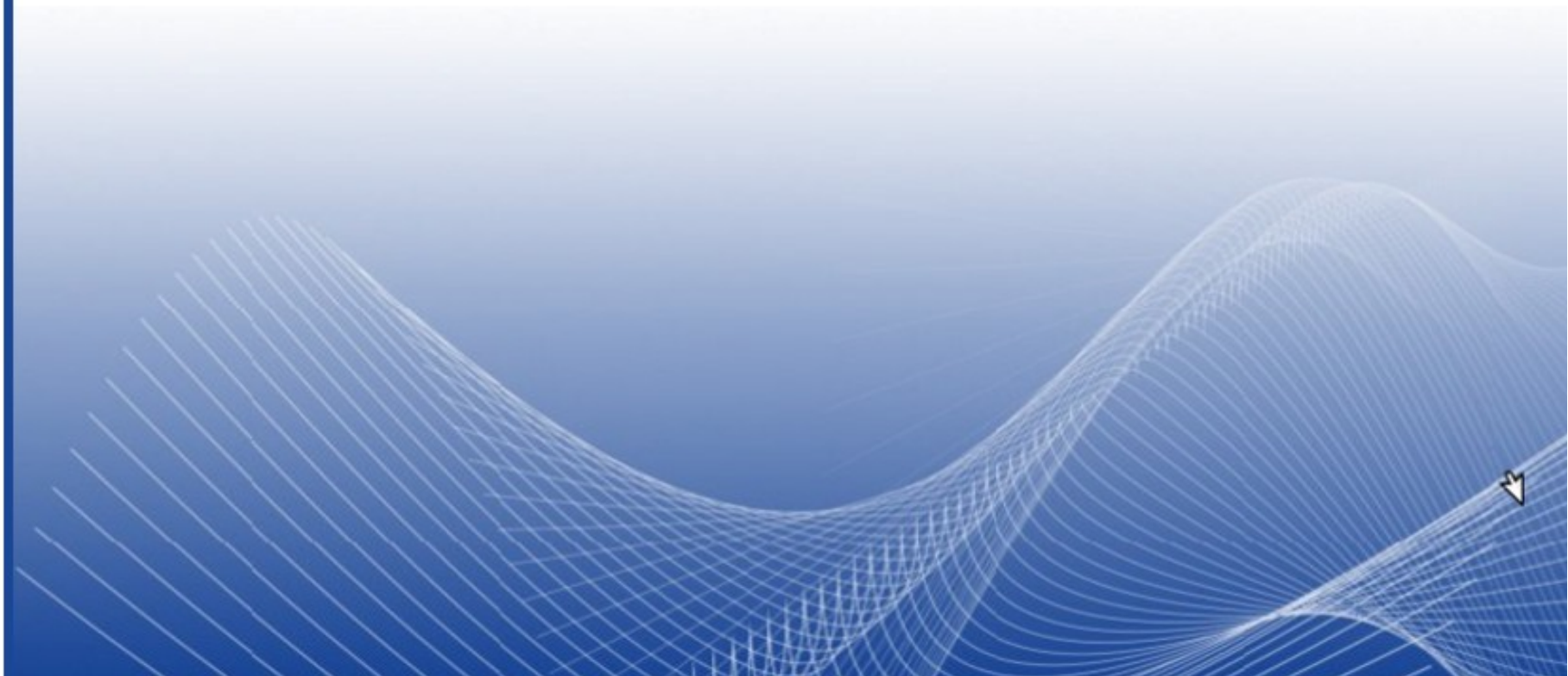
DHCP



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Dynamic Host Configuration Protocol (DHCP)

- Serviço de atribuição dinâmica de endereços IP a terminais
- Segue uma filosofia cliente-servidor
- Aluguer de endereços
- Configuração dos terminais com informação de máscara da rede, *default gateway*, servidores de DNS, servidores de WINS e domínio DNS

Configuração de um servidor DHCP

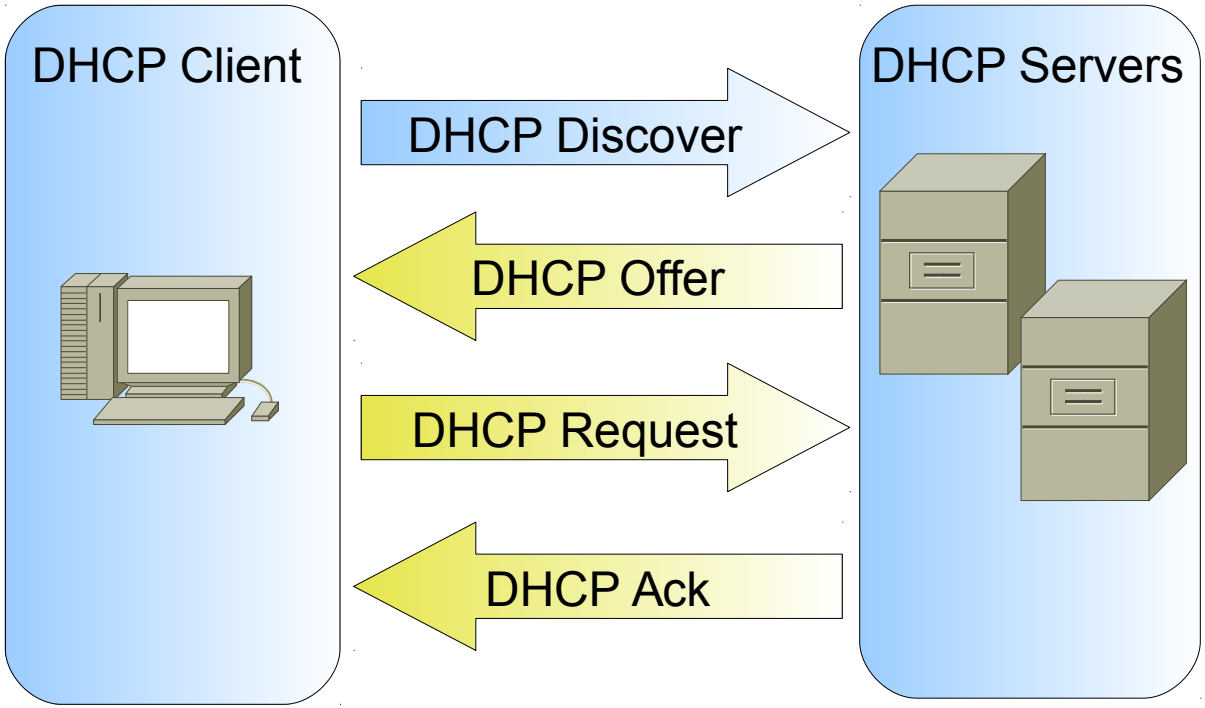
- Gama de endereços
  - Conjunto de endereços IP definido por um endereço inicial e um endereço final
- Gama(s) de exclusão
  - Conjuntos de endereços IP que se querem excluir
- Endereços reservados
  - Endereços IP atribuídos de uma forma permanente a endereços MAC
- Duração dos alugueres

Protocolo DHCP (IETF RFC 2131)

- Extensão *Bootstrap Protocol,* BOOTP, (RFC 1542)
  - Corre sobre o UDP Número de porto do Servidor: 67
    Número de porto do Cliente: 68
  - O BOOTP permite que um terminal sem disco descubra o seu endereço IP, um endereço de um servidor e o nome de um ficheiro a pedir ao servidor para ser copiado para memória e executado localmente.
- Protocolo de aluguer em quatro fases:
  - *Discover*
  - *Offer*
  - *Request*
  - *Acknowledge*

1ª Fase: *Discover*

A mensagem *DHCP Discover* é encapsulada num pacote *BootP Request*. Serve para descobrir os servidores de DHCP existentes na rede. O cliente pode também indicar qual o endereço IP que pretende alugar.



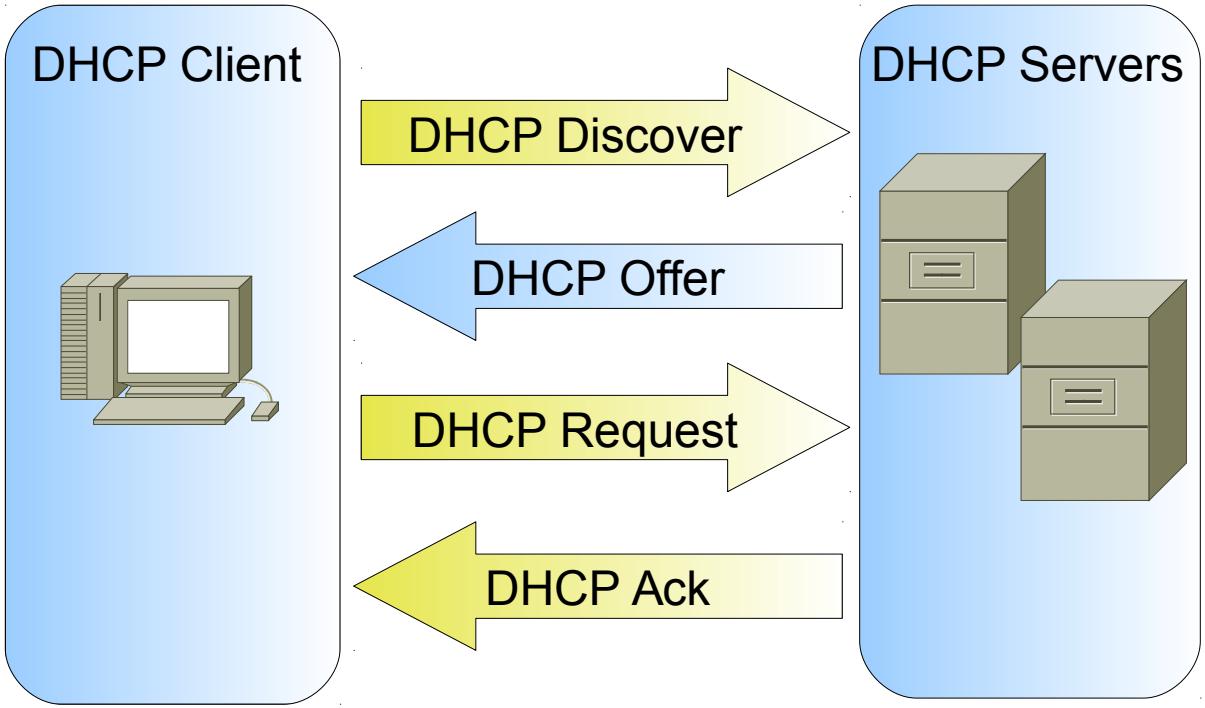
DHCP Discover

No.	Time	Source	Destination	Protocol	Info
1326	20.269579	0.0.0.0	255.255.255.255	DHCP	DHCP Discover
1337	20.561380	193.136.92.65	193.136.93.228	DHCP	DHCP Offer
1338	20.561592	0.0.0.0	255.255.255.255	DHCP	DHCP Request
1340	20.569560	193.136.92.65	193.136.93.228	DHCP	DHCP ACK

```
▷ Frame 1326 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e), Dst: ff:ff:ff:ff:ff:ff (ff
▷ Internet Protocol, Src: 0.0.0.0 (0.0.0.0), Dst: 255.255.255.255 (255.255.255.255)
▷ User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
▽ Bootstrap Protocol
    Message type: Boot Request (1)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x42f5a54a
    Seconds elapsed: 0
  ▷ Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 0.0.0.0 (0.0.0.0)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP Discover
  ▷ Option: (t=50,l=4) Requested IP Address = 192.168.1.71
  ▷ Option: (t=12,l=15) Host Name = "salvador-laptop"
  ▷ Option: (t=55,l=13) Parameter Request List
    End Option
    Padding
```

2ª Fase: *Offer*

A mensagem *DHCP Offer* é encapsulada num pacote *BootP Reply*. Cada servidor indica um endereço IP para ser alugado (se possível, os servidores respeitam a preferência do cliente).



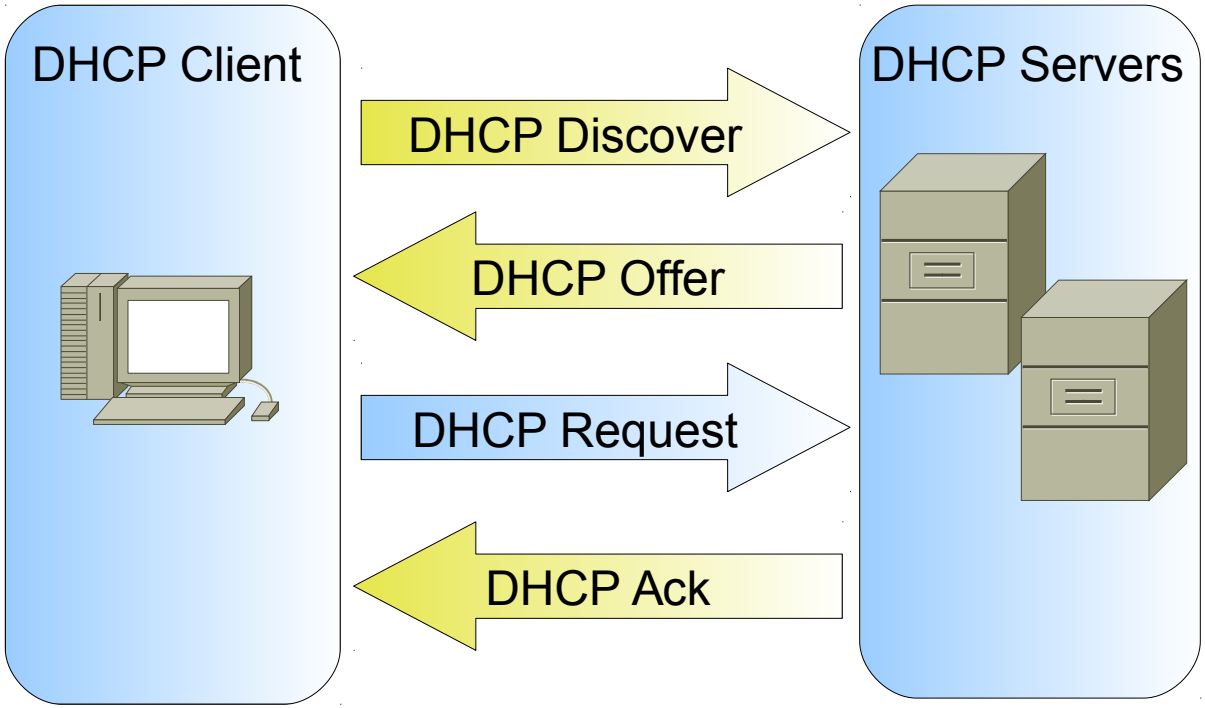
DHCP Offer

No.	Time	Source	Destination	Protocol	Info
1326	20.269579	0.0.0.0	255.255.255.255	DHCP	DHCP Discover
1337	20.561380	193.136.92.65	193.136.93.228	DHCP	DHCP Offer
1338	20.561592	0.0.0.0	255.255.255.255	DHCP	DHCP Request
1340	20.569560	193.136.92.65	193.136.93.228	DHCP	DHCP ACK

```
▷ Frame 1337 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: 00:d0:b7:17:5b:6d (00:d0:b7:17:5b:6d), Dst: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
▷ Internet Protocol, Src: 193.136.92.65 (193.136.92.65), Dst: 193.136.93.228 (193.136.93.228)
▷ User Datagram Protocol, Src Port: bootps (67), Dst Port: bootpc (68)
▽ Bootstrap Protocol
    Message type: Boot Reply (2)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x42f5a54a
    Seconds elapsed: 0
  ▷ Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 193.136.93.228 (193.136.93.228)
    Next server IP address: 193.136.92.65 (193.136.92.65)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP Offer
  ▷ Option: (t=54,l=4) DHCP Server Identifier = 193.136.92.65
  ▷ Option: (t=51,l=4) IP Address Lease Time = 10 minutes
  ▷ Option: (t=1,l=4) Subnet Mask = 255.255.254.0
  ▷ Option: (t=3,l=4) Router = 193.136.92.1
  ▷ Option: (t=15,l=8) Domain Name = "av.it.pt"
  ▷ Option: (t=6,l=4) Domain Name Server = 193.136.92.65
    End Option
    Padding
```

3ª Fase: *Request*

A mensagem *DHCP Request* é encapsulada num pacote *BootP Request*. Após escolha entre as possíveis diferentes ofertas recebidas, o cliente indica qual o endereço IP pretendido.



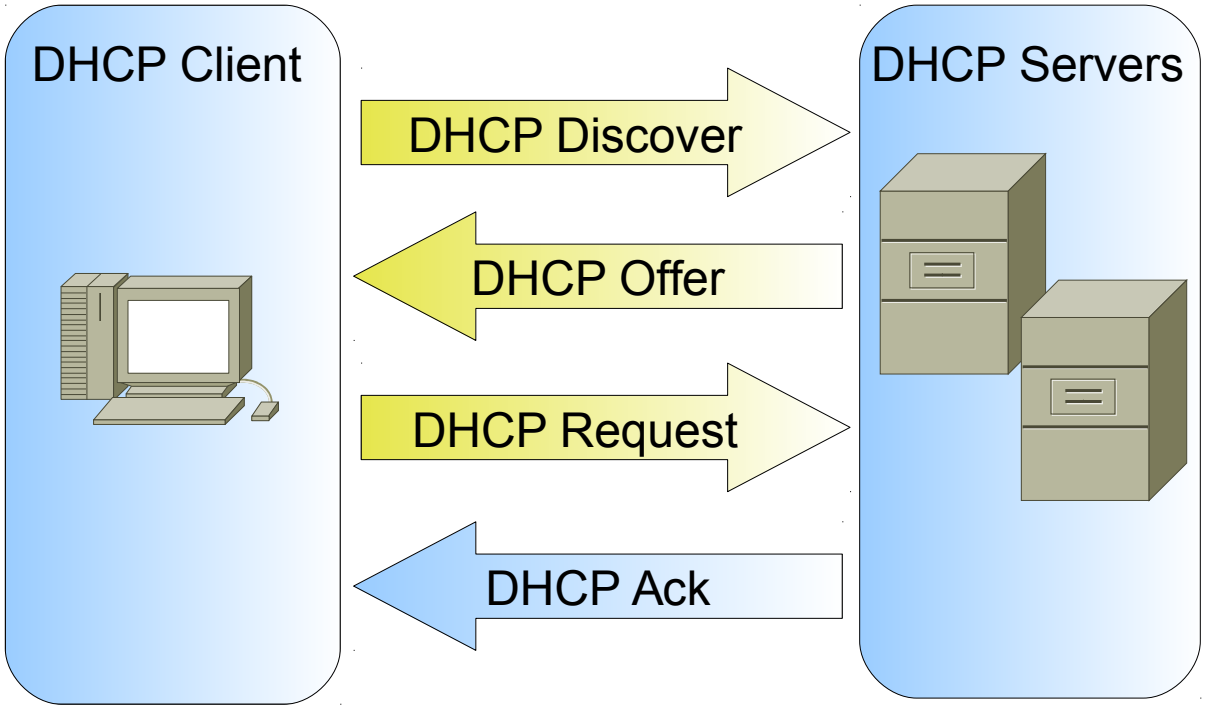
DHCP Request

No.	Time	Source	Destination	Protocol	Info
1326	20.269579	0.0.0.0	255.255.255.255	DHCP	
1337	20.561380	193.136.92.65	193.136.93.228	DHCP	
1338	20.561592	0.0.0.0	255.255.255.255	DHCP	
1340	20.569560	193.136.92.65	193.136.93.228	DHCP	

```
▷ Frame 1338 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e), Dst: ff:ff:ff:ff:ff:ff (ff:ff:ff:ff:ff:ff)
▷ Internet Protocol, Src: 0.0.0.0 (0.0.0.0), Dst: 255.255.255.255 (255.255.255.255)
▷ User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
▽ Bootstrap Protocol
    Message type: Boot Request (1)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x42f5a54a
    Seconds elapsed: 0
  ▷ Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 0.0.0.0 (0.0.0.0)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP Request
  ▷ Option: (t=54,l=4) DHCP Server Identifier = 193.136.92.65
  ▷ Option: (t=50,l=4) Requested IP Address = 193.136.93.228
  ▷ Option: (t=12,l=15) Host Name = "salvador-laptop"
  ▷ Option: (t=55,l=13) Parameter Request List
    End Option
    Padding
```

4ª Fase: *Acknowledge*

A mensagem *DHCP Ack* é encapsulada num pacote *BootP Reply*. O servidor identifica positivamente o aluguer do endereço IP indicado fornecendo simultaneamente outras informações de interesse.



DHCP Ack

No.	Time	Source	Destination	Protocol	Info
1326	20.269579	0.0.0.0	255.255.255.255	DHCP	DHCP Discover
1337	20.561380	193.136.92.65	193.136.93.228	DHCP	DHCP Offer
1338	20.561592	0.0.0.0	255.255.255.255	DHCP	DHCP Request
1340	20.569560	193.136.92.65	193.136.93.228	DHCP	DHCP ACK

```
▷ Frame 1340 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: 00:d0:b7:17:5b:6d (00:d0:b7:17:5b:6d), Dst: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
▷ Internet Protocol, Src: 193.136.92.65 (193.136.92.65), Dst: 193.136.93.228 (193.136.93.228)
▷ User Datagram Protocol, Src Port: bootps (67), Dst Port: bootpc (68)
▽ Bootstrap Protocol
    Message type: Boot Reply (2)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x42f5a54a
    Seconds elapsed: 0
  ▷ Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0 (0.0.0.0)
    Your (client) IP address: 193.136.93.228 (193.136.93.228)
    Next server IP address: 193.136.92.65 (193.136.92.65)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP ACK
  ▷ Option: (t=54,l=4) DHCP Server Identifier = 193.136.92.65
  ▷ Option: (t=51,l=4) IP Address Lease Time = 10 minutes
  ▷ Option: (t=1,l=4) Subnet Mask = 255.255.254.0
  ▷ Option: (t=3,l=4) Router = 193.136.92.1
  ▷ Option: (t=15,l=8) Domain Name = "av.it.pt"
  ▷ Option: (t=6,l=4) Domain Name Server = 193.136.92.65
    End Option
    Padding
```

Protocolo DHCP

- Aluguer de endereços
  - *T1 Time (50%* do *Lease Time)* – tempo ao fim do qual o terminal deve tentar renovar o aluguer
  - *T2 Time (85%* do *Lease Time)* – tempo ao fim do qual o terminal deve tentar novamente renovar o aluguer se a primeira tentativa não for bem sucedida
  - *Lease Time* – tempo ao fim do qual o terminal deve deixar de usar o endereço IP se o aluguer não for renovado
- Existência de múltiplos servidores DHCP
  - Vantagem: redundância a falhas de funcionamento
  - Requisito: gamas disjuntas de endereços nos diferentes servidores

Outras mensagens DHCP

- DHCP Decline:
  - O cliente rejeita a oferta que lhe foi feita e reinicia o processo de aluguer de endereço
- DHCP Nack:
  - O servidor informa que não pode satisfazer o pedido que este lhe fez, através da mensagem DHCP Request
- DHCP Release:
  - O cliente informa que pretende terminar o aluguer
- DHCP Inform:
  - O cliente solicita apenas alguns parâmetros (neste caso, o cliente já tem um endereço IP, mas pretende solicitar, por exemplo, o endereço de um servidor DNS)

DHCP Release

No.	Time	Source	Destination	Protocol	Info
1330	24.011686	193.136.93.228	193.136.92.65	DHCP	DHCP Release

```
▷ Frame 1330 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e), Dst: 00:d0:b7:17:5b:6d (00:d0:b7:17:5b:6d)
▷ Internet Protocol, Src: 193.136.93.228 (193.136.93.228), Dst: 193.136.92.65 (193.136.92.65)
▷ User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
▽ Bootstrap Protocol
    Message type: Boot Request (1)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0xc099a870
    Seconds elapsed: 0
  ▷ Bootp flags: 0x0000 (Unicast)
    Client IP address: 193.136.93.228 (193.136.93.228)
    Your (client) IP address: 0.0.0.0 (0.0.0.0)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: 00:1d:ba:c0:a2:8e (00:1d:ba:c0:a2:8e)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP Release
  ▷ Option: (t=54,l=4) DHCP Server Identifier = 193.136.92.65
  ▷ Option: (t=12,l=15) Host Name = "salvador-laptop"
    End Option
    Padding
```

DHCP Inform

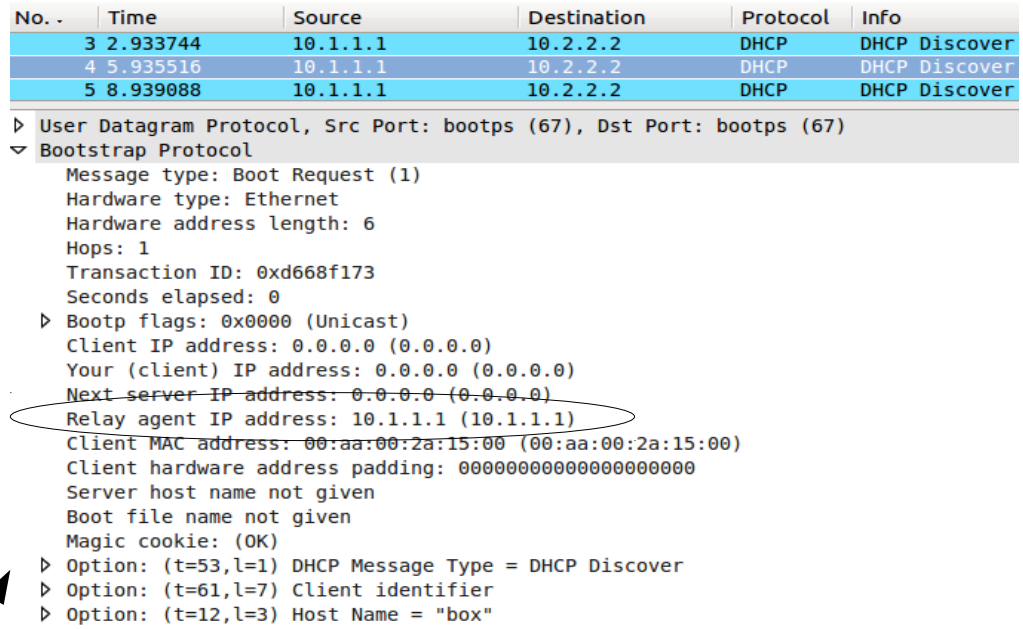
No.	Time	Source	Destination	Protocol	Info
4107	65.374546	193.136.93.173	255.255.255.255	DHCP	DHCP Inform
5446	86.143470	193.136.93.102	255.255.255.255	DHCP	DHCP Inform

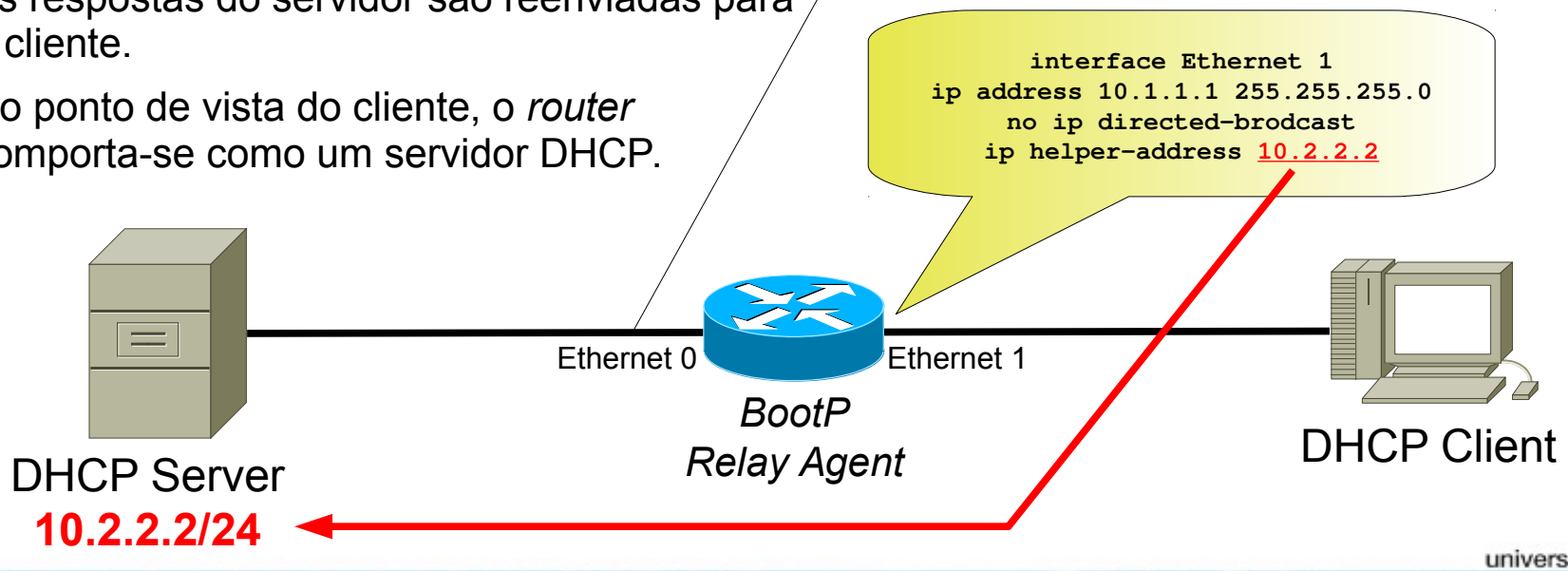
```
▷ Frame 4107 (342 bytes on wire, 342 bytes captured)
▷ Ethernet II, Src: d0:df:9a:cb:d1:3c (d0:df:9a:cb:d1:3c), Dst: ff:ff:ff:ff:ff:ff (ff:ff:ff:ff:ff:ff)
▷ Internet Protocol, Src: 193.136.93.173 (193.136.93.173), Dst: 255.255.255.255 (255.255.255.255)
▷ User Datagram Protocol, Src Port: bootpc (68), Dst Port: bootps (67)
▽ Bootstrap Protocol
    Message type: Boot Request (1)
    Hardware type: Ethernet
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0xfb8eebf9
    Seconds elapsed: 0
  ▷ Bootp flags: 0x8000 (Broadcast)
    Client IP address: 193.136.93.173 (193.136.93.173)
    Your (client) IP address: 0.0.0.0 (0.0.0.0)
    Next server IP address: 0.0.0.0 (0.0.0.0)
    Relay agent IP address: 0.0.0.0 (0.0.0.0)
    Client MAC address: d0:df:9a:cb:d1:3c (d0:df:9a:cb:d1:3c)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: (OK)
  ▷ Option: (t=53,l=1) DHCP Message Type = DHCP Inform
  ▷ Option: (t=61,l=7) Client identifier
  ▷ Option: (t=12,l=7) Host Name = "IT-TOSH"
  ▷ Option: (t=60,l=8) Vendor class identifier = "MSFT 5.0"
  ▷ Option: (t=55,l=13) Parameter Request List
    End Option
    Padding
```

```
▽ Option: (t=55,l=13) Parameter Request List
    Option: (55) Parameter Request List
    Length: 13
    Value: 010F03062C2E2F1F2179F92BFC
    1 = Subnet Mask
    15 = Domain Name
    3 = Router
    6 = Domain Name Server
    44 = NetBIOS over TCP/IP Name Server
    46 = NetBIOS over TCP/IP Node Type
    47 = NetBIOS over TCP/IP Scope
    31 = Perform Router Discover
    33 = Static Route
    121 = Classless Static Route
    249 = Private/Classless Static Route (Microsoft)
    43 = Vendor-Specific Information
    252 = Private/Proxy autodiscovery
```

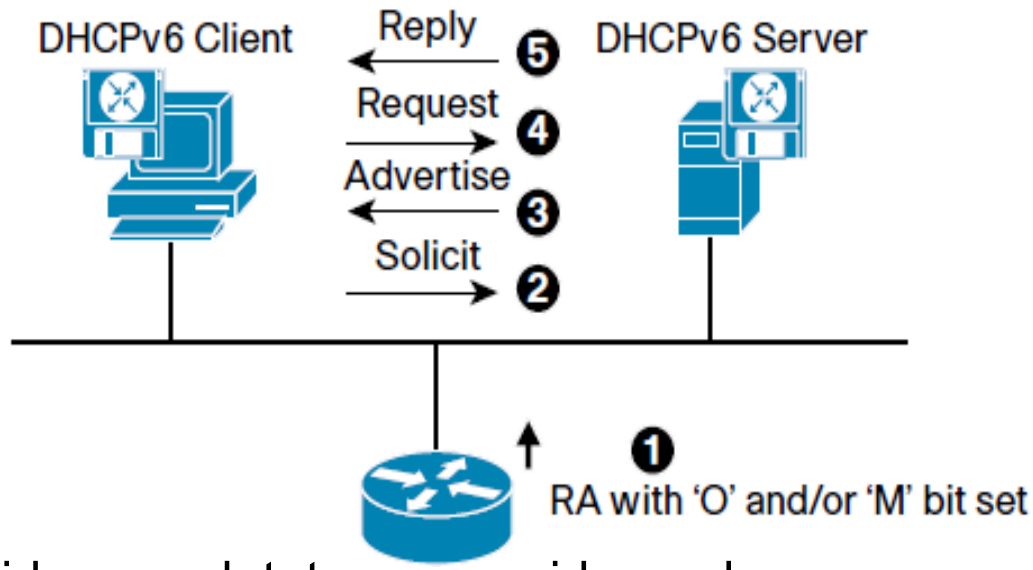
Uso de Servidores DHCP em Ambientes Complexos

- Em ambientes de rede complexos onde um (ou mais) servidor DHCP fornece endereços a múltiplas redes locais (subredes IP).
- O *gateway* de cada rede local deverá ser configurado como "*BootP Relay Agent*".
- O router irá redirecionar todos os pacotes DHCP (recebidos em *broadcast*) para o servidor DHCP usando *unicast*.
  - Adiciona informação na mensagem com a indicação da rede/interface onde recebeu o pedido.
  - As respostas do servidor são reenviadas para o cliente.
  - Do ponto de vista do cliente, o *router* comporta-se como um servidor DHCP.



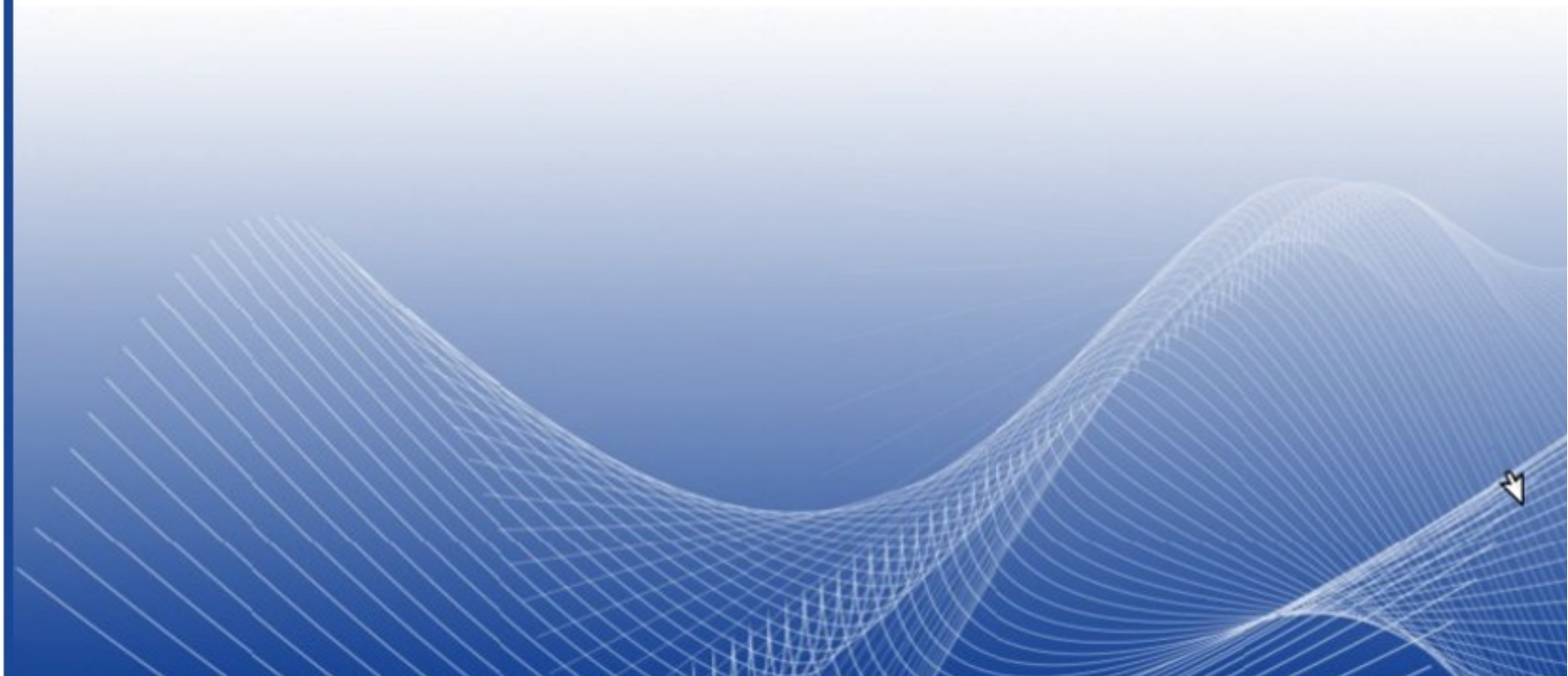


DHCPv6



- Usado para obter endereços IPv6 e/ou parâmetros de rede IPv6.
- Conceito similar ao do DHCP para IPv4.
- Um terminal que queira receber quaisquer parâmetros de configuração irá enviar um pedido para detetar os servidores de DHCPv6 disponíveis.
  - Usando a mensagem "Solicit".
  - O endereço de destino da mensagem "Solicit" é um endereço de multicast específico do DHCPv6.
  - As respostas virão em mensagens "Advertise".
- De seguida, o cliente DHCPv6 irá enviar um pedido usando uma mensagem "Request". O servidor de DHCPv6 irá responder com a informação pedida usando uma mensagem "Reply".
- O relay em DHCPv6 funciona de forma distinta do que no DHCP para IPv4.
  - O Relay Agent encapsula completamente as mensagens DHCPv6 do cliente numa nova mensagem do tipo RELAY-FORW message.
  - Reencaminha esta nova mensagem para o servidor de DHCPv6.
  - A resposta é feita igualmente usadndo uma nova mensagem (RELAY-REPL message) que contem encapsulada a mensagem a enviar ao cliente DHCPv6 pelo Relay Agent.

DNS



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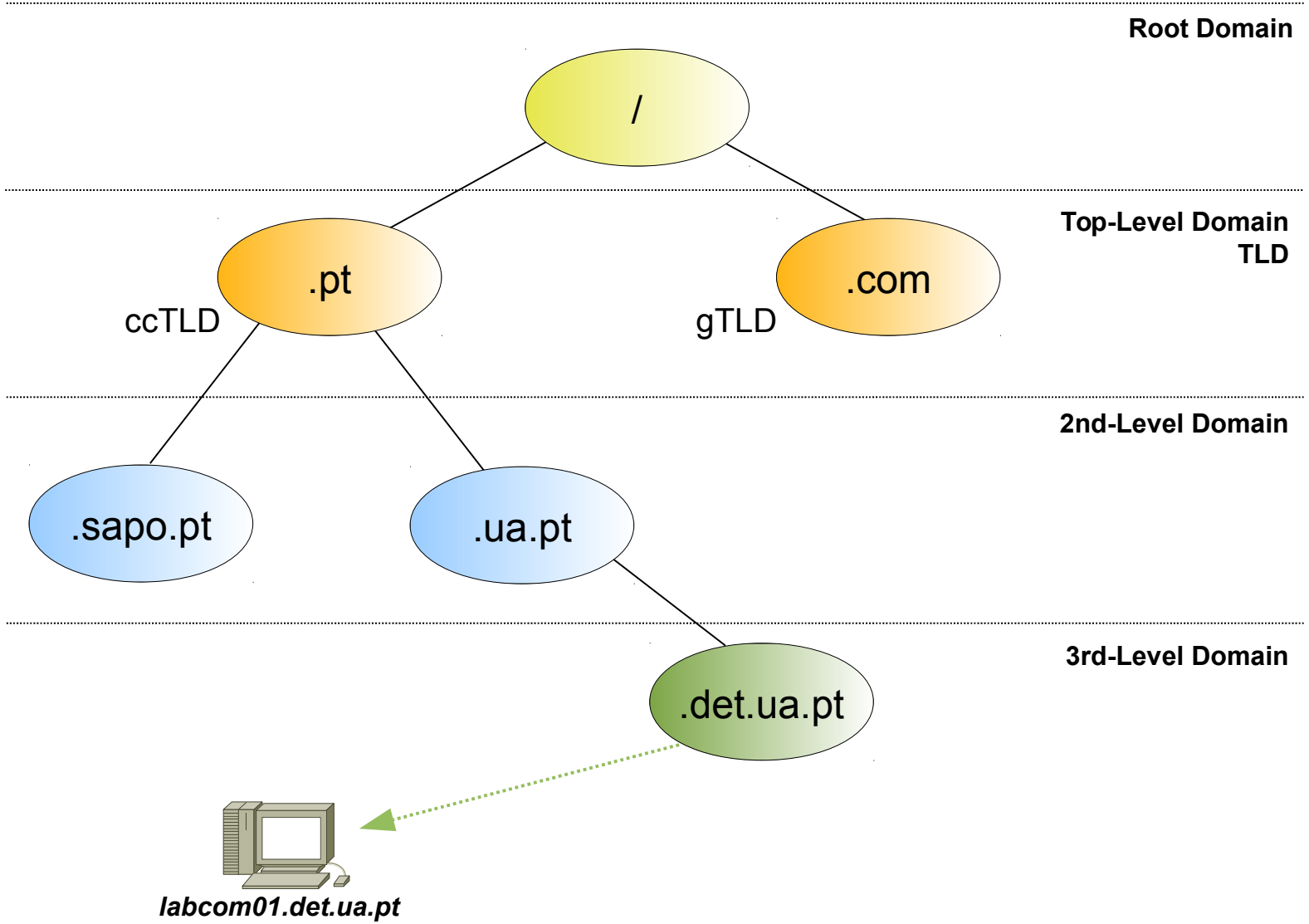
Domain Name System (DNS)

- Distributed database system that facilitates a translation service (resolution) between host names and IP addresses.
- Allows also the translation/resolution between IP addresses and host names
  - The name ”DD.CC.BB.AA.**in-addr.arpa**” allows the resolution of the IPv4 address AA.BB.CC.DD
  - The name 0.0.0.0.8.b.d.0.1.0.0.2.**ip6.arpa** allows the resolution of the IPv6 address 2001:0db8:0000::/48
  - Resolution name-ip and ip-name is not symmetrical.
- Organizes the names in domains according to an hierarchical structure.
- Each DNS system defines one or more zones over which has the resolution authority.

Hierarchical Structure of Domain Names



Root Servers & Root Zone File

- Root servers

- Root Zone File (sample)

```
.....
COM. NS A.GTLD-SERVERS.NET.
COM. NS G.GTLD-SERVERS.NET.
COM. NS H.GTLD-SERVERS.NET.
COM. NS C.GTLD-SERVERS.NET.
.....
PT. NS NS.DNS.BR.
PT. NS NS2.NIC.FR.
PT. NS NS.DNS.PT.
PT. NS SUNIC.SUNET.SE.
PT. NS NS2.DNS.PT.
PT. NS NS-EXT.ISC.ORG.
.....
NET. NS A.GTLD-SERVERS.NET.
NET. NS G.GTLD-SERVERS.NET.
NET. NS H.GTLD-SERVERS.NET.
NET. NS C.GTLD-SERVERS.NET.
.....
INFO. NS B0.INFO.AFILIAS-NST.ORG.
INFO. NS C0.INFO.AFILIAS-NST.INFO.
INFO. NS D0.INFO.AFILIAS-NST.ORG.
.....
```

Top-Level Domains (TLD)

- gTLDs (generic TLDs)
  - .com, .edu, .gov, .mil, .net, .org, .int, .aero, .biz, .coop, .info, .museum, .name, .pro, .cat, .jobs, .mobi, .travel, .tel, .asia
- ccTLDs (country code TLDs)
  - 2 letter domains that identify a specific country (ISO 3166)
  - Management is delegated (by ICANN) to a governmental institution from each country.
    - Those can (re)-delegate in private companies.
  - Ex: .pt, .es, .us, .fr, etc...
- New gTLDs (under approval)
  - .**amazon**, .app, .**apple**, .bank, .bet, .blog, .book, .cars, .**goog**, .**goggle**, .hotel, ...

TLD Zone Files (sample)

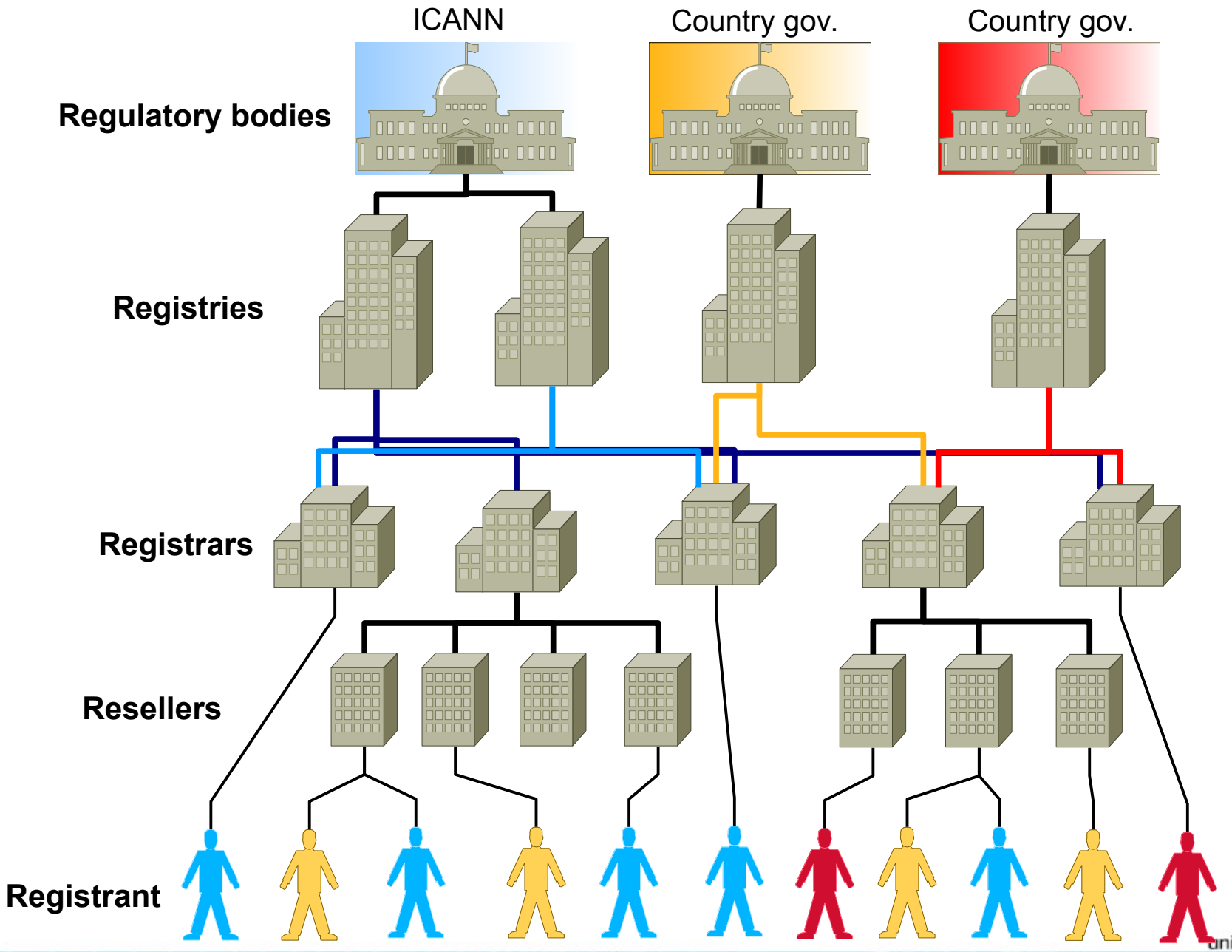
- .ORG (Public Interest Registry)

```
.....
AASELFSTORAGE.ORG. NS DNS02.GPN.REGISTER.COM.
AASELFSTORAGE.ORG. NS DNS03.GPN.REGISTER.COM.
AASELFSTORAGE.ORG. NS DNS04.GPN.REGISTER.COM.
AASELFSTORAGE.ORG. NS DNS05.GPN.REGISTER.COM.
AASEMI.ORG. NS DPNS1.DNSNAMESERVER.ORG.
AASEMI.ORG. NS DPNS2.DNSNAMESERVER.ORG.
AASEMI.ORG. NS DPNS3.DNSNAMESERVER.ORG.
AASEMI.ORG. NS DPNS4.DNSNAMESERVER.ORG.
AASEN.ORG. NS NS1.MAILBANK.COM.
AASEN.ORG. NS NS2.MAILBANK.COM.
AASENIORMORTGAGE.ORG. NS NS13.DOMAINCONTROL.COM.
AASENIORMORTGAGE.ORG. NS NS14.DOMAINCONTROL.COM.
AASENT.ORG. NS NS51.1AND1.COM.
AASENT.ORG. NS NS52.1AND1.COM.
AASENTMORTGAGE.ORG. NS NS51.1AND1.COM.
AASENTMORTGAGE.ORG. NS NS52.1AND1.COM.
AASENY.ORG. NS NS27.1AND1.COM.
AASENY.ORG. NS NS28.1AND1.COM.
AASEP.ORG. NS NS1.CASTIRONCODING.COM.
AASEP.ORG. NS NS2.CASTIRONCODING.COM.
AASERV.ORG. NS NS1.RENEWYOURNAME.NET.
.....
```

- .COM (Verisign)

```
.....
AMERICANHUNTING NS NS1.HITFARM
AMERICANHUNTING NS NS2.HITFARM
ATSCAF NS CBRU.BR.NS.ELS-GMS.ATT.NET.
ATSCAF NS CMTU.MT.NS.ELS-GMS.ATT.NET.
ACTIONNETS NS NS.TULSAWEB
ACTIONNETS NS NS.TIBP
ACI-APPLICAD NS NS2.WEBNJ.NET.
ACI-APPLICAD NS NS1.WEBNJ.NET.
ANZAPACK NS DNS3.TERRA.ES.
ANZAPACK NS DNS4.TERRA.ES.
ALPHASOFTDE NS DNS1.EPAG.NET.
ALPHASOFTDE NS DNS2.EPAG.NET.
ALPHASOFTDE NS DNS01.KUTTIG.NET.
AAI-TENN NS AUTH00.DNS.BELLSOUTH.NET.
AAI-TENN NS AUTH01.DNS.BELLSOUTH.NET.
AAI-TENN NS AUTH02.DNS.BELLSOUTH.NET.
ALLIEDMAXCUT NS NS3.DHCNET.NET.
ALLIEDMAXCUT NS NS0.DHCNET.NET.
ATLANTAEXOTICS NS NS1.APHOST
ATLANTAEXOTICS NS NS2.APHOST
ATLANTA-EXOTICS NS NS3.LNHI.NET.
ATLANTA-EXOTICS NS NS2.LNHI.NET.
ATLANTA-EXOTICS NS NS1.LNHI.NET.
.....
```

Domain Management Model (1)

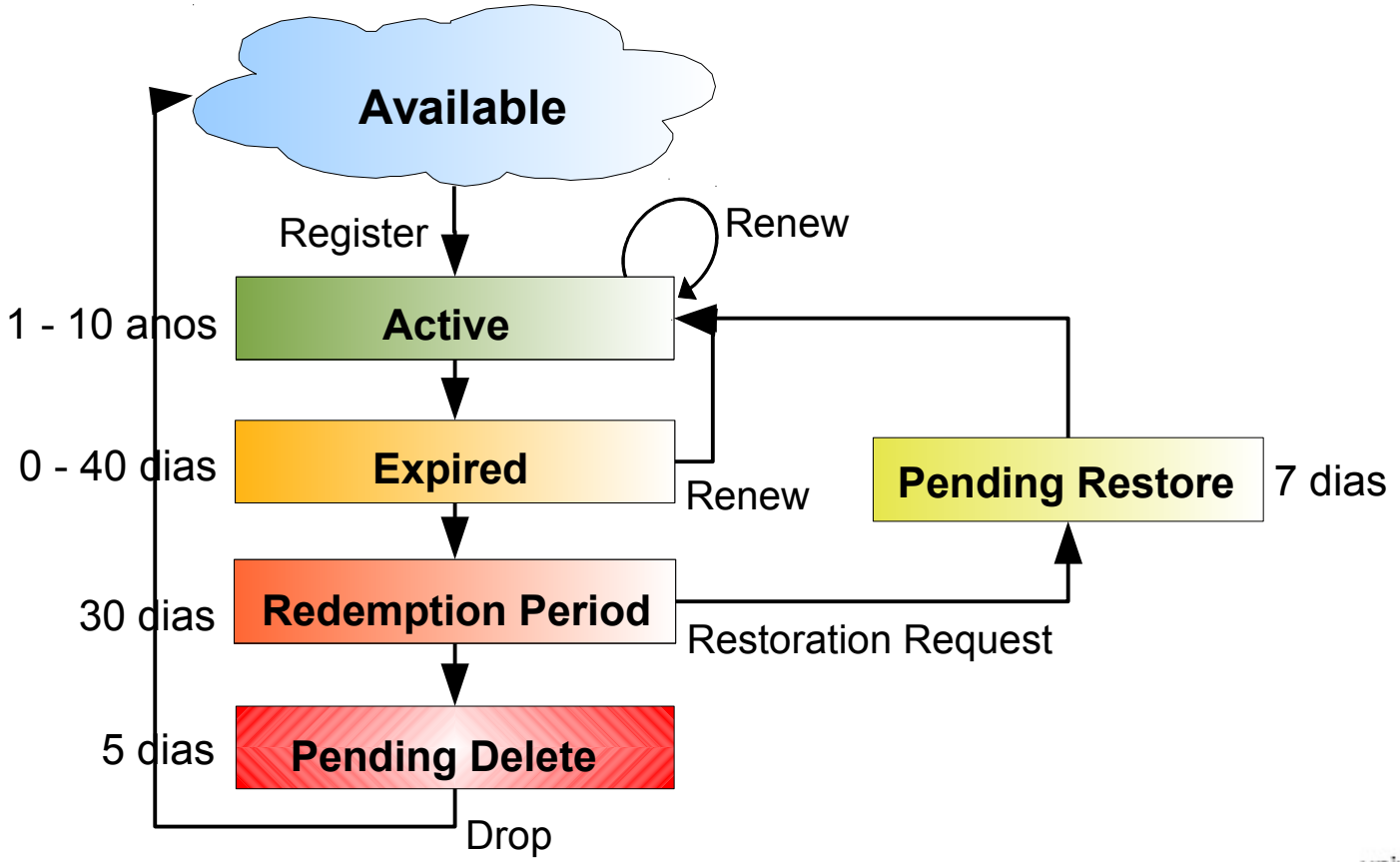


Domain Management Model (2)

- Delegation and Authority lie at the core of the domain name system hierarchy.
- The Authority for the root domain lies with Internet Corporation for Assigned Numbers and Names (ICANN).
  - gTLDs are authoritatively administered by ICANN and delegated to a series of accredited entities.
  - ccTLDs are delegated to the individual countries for administration purposes.
- The entity responsible by a specif domain is called **Registry**.
  - In charge of maintaining the Zone File of the TLD.
- **Registries** (usually) delegate in **Registrar** the operational management and marketing of a domain.
  - One **Registry** can delegate to multiple **Registrars**
  - The **Registrar** stores and manages the information and status of a domain.
- One **Registrar** may still accept **Resellers**
  - A **Reseller** sells domains from a **Registrar** (for a commission)
  - The management of the domains is not responsibility of a **Reseller.**
- A **Registrant** is any entity that want to register a domain name.

Domain Name Life Cycle

- A domain can be registered for a period of 1 to 10 years.
  - After that period the domain must be renewed.
- In case of no renewal, it's initiated the process of deletion of the domain name from the DNS database.
  - Nowadays, the Registrars do not release the domain immediately after the redemption period, they initiate a reselling mechanism (usually some kind of auction) of the domain on the secondary market.



WHOIS Service and Information

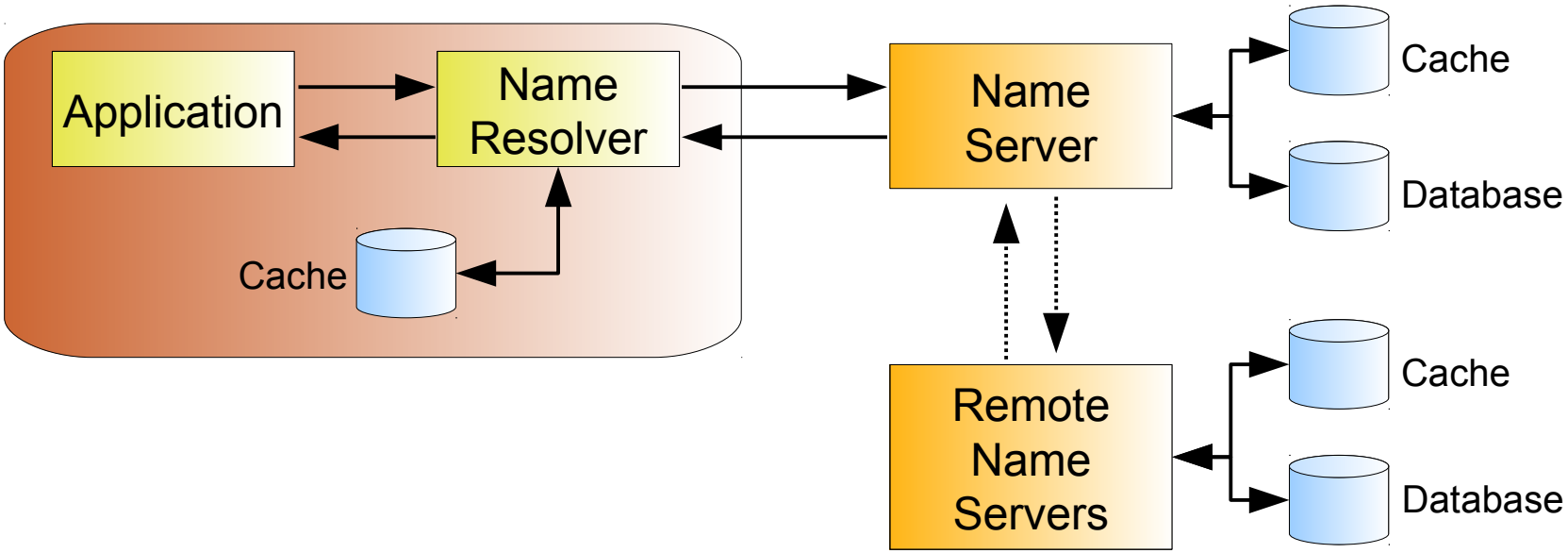
- Contains information about the registrant of a domain
  - Name servers
  - Status of the domain
    - Registry-Registrar Protocol (RPP)
    - Extensible Provisioning Protocol(EPP)
  - Creation, expiration and last update dates.
  - Registrant contacts
    - General
    - Administrative
    - Technical
    - Billing
- This information can be retrieved using the WHOIS service
  - Executes recursive queries of Registry and Registrant databases.

```
Domain Name: NAME.COM
Registrar: NAME.COM LLC
Whois Server: whois.name.com
Referral URL: http://www.name.com
Name Server: NS1.NAME.COM
Name Server: NS2.NAME.COM
Name Server: NS3.NAME.COM
Name Server: NS4.NAME.COM
Status: ok
Updated Date: 30-jan-2009
Creation Date: 03-jan-1995
Expiration Date: 04-nov-2015
.....
REGISTRANT CONTACT INFO
Name.com LLC
DNS Admin, 125 Rampart Way, Suite 300, Denver, CO 80230, US
Phone:        +1.7202492374
Email Address: dns@name.com

ADMINISTRATIVE CONTACT INFO
Name.com LLC
DNS Admin, 125 Rampart Way, Suite 300, Denver, CO 80230, US
Phone:        +1.7202492374
Email Address: dns@name.com

TECHNICAL CONTACT INFO
Name.com LLC
DNS Admin, 125 Rampart Way, Suite 300, Denver, CO 80230, US
Phone:        +1.7202492374
Email Address: dns@name.com

BILLING CONTACT INFO
Name.com LLC
DNS Admin, 125 Rampart Way, Suite 300, Denver, CO 80230, US
Phone:        +1.7202492374
Email Address: dns@name.com
```

Name Servers Registration

- In order to set up a DNS server outside of your registrar, you need to:
  - Explicitly register your name server names and IPs.
    - i.e. Associate name with IP (ex: ns1.domain.com – 10.1.1.1).
  - Define server names (minimum 2) to your domain registration at your registrar.

Name Resolution



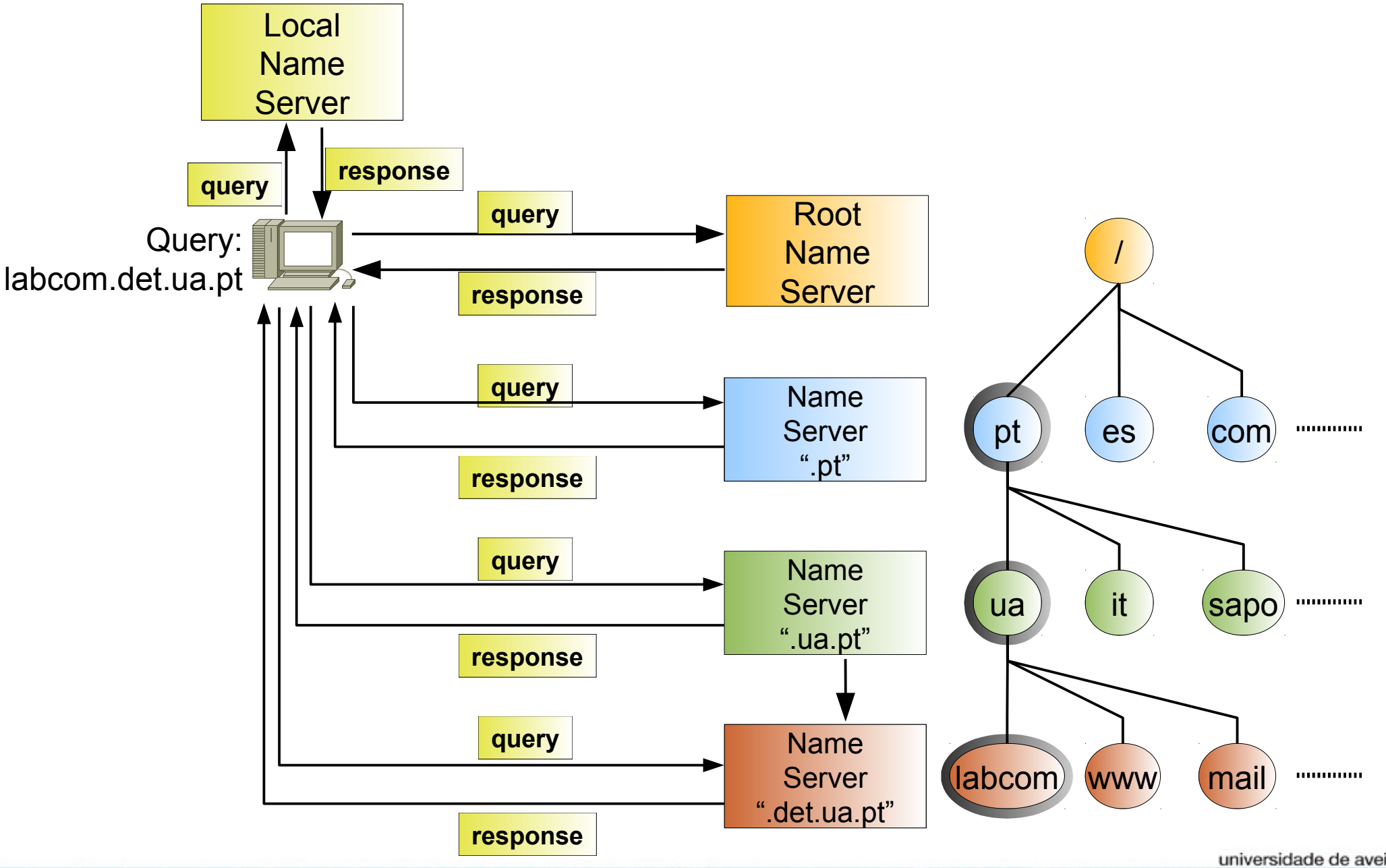
- Received answers are (may be) temporarily stored in cache (have an associated TTL)
  - Can be reused in future queries to speed up answers.
- Cache use improves the systems efficiency by eliminating unnecessary external queries.

DNS Query & DNS Response

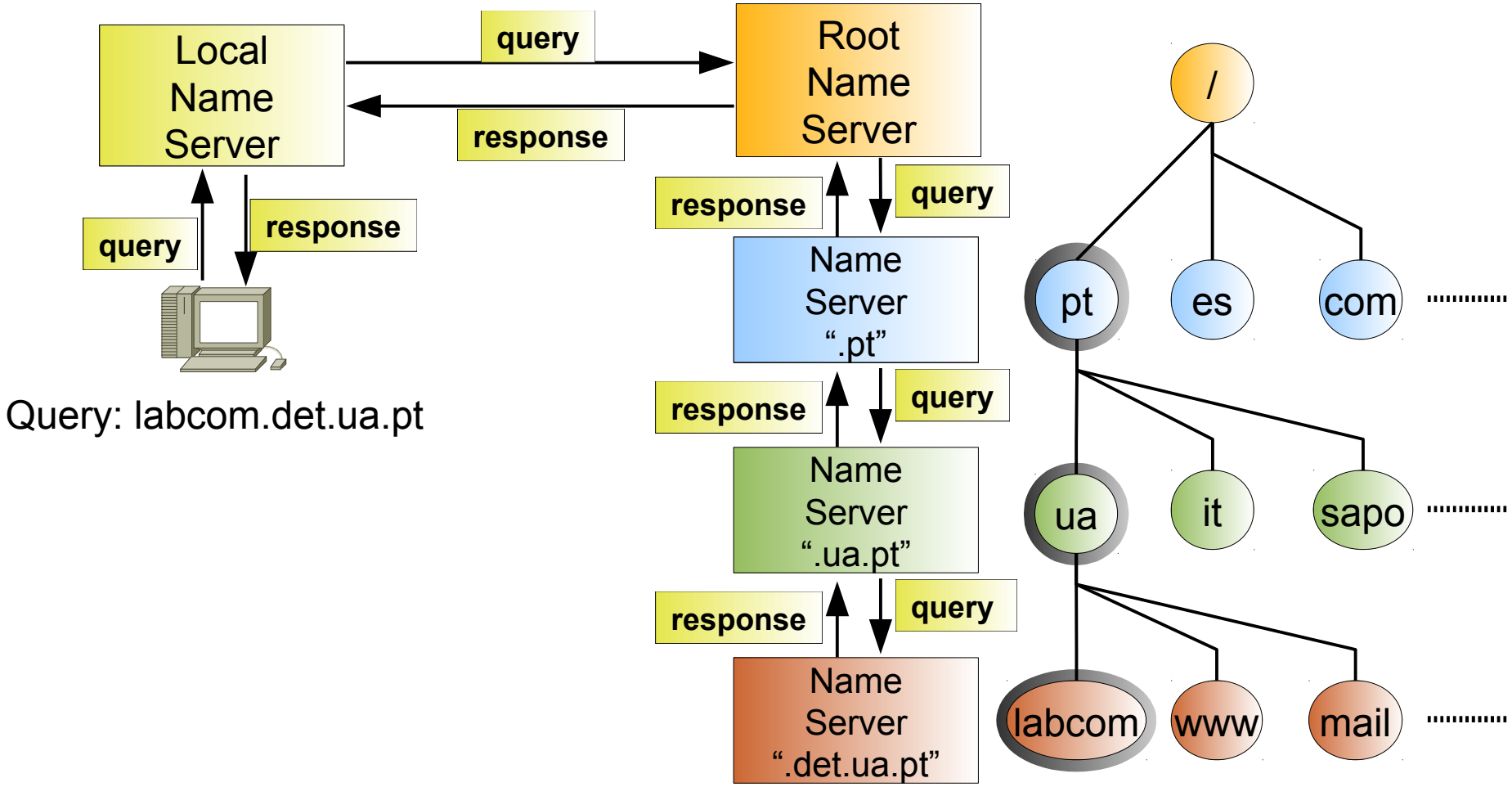
```
Frame 1928 (69 bytes on wire, 69 bytes captured)
Ethernet II, Src: 00:15:f2:9f:38:9d, Dst:
00:60:08:1f:b8:26
Internet Protocol, Src: 193.136.92.160, Dst:
193.136.92.65
User Datagram Protocol, Src Port: 54277, Dst Port: 53
    Source port: 54277 (54277)
    Destination port: 53 (53)
    Length: 35
    Checksum: 0x3c27 [incorrect, should be 0xabba
(maybe caused by "UDP checksum offload"?)]
Domain Name System (query)
    [Response In: 1929]
    Transaction ID: 0xf1e4
    Flags: 0x0100 (Standard query)
    Questions: 1
    Answer RRs: 0
    Authority RRs: 0
    Additional RRs: 0
    Queries
        www.ua.pt: type A, class I
```

```
Frame 1929 (152 bytes on wire, 152 bytes captured)
Ethernet II, Src: 00:60:08:1f:b8:26, Dst:
00:15:f2:9f:38:9d
Internet Protocol, Src: 193.136.92.65, Dst:
193.136.92.160
User Datagram Protocol, Src Port: 53, Dst Port: 54277
    Source port: 53 (53)
    Destination port: 54277 (54277)
    Length: 118
    Checksum: 0x1167 [correct]
Domain Name System (response)
    [Request In: 1928]
    [Time: 0.005100000 seconds]
    Transaction ID: 0xf1e4
    Flags: 0x8180 (Standard query response, No error)
    Questions: 1
    Answer RRs: 1
    Authority RRs: 2
    Additional RRs: 2
    Queries
        www.ua.pt: type A, class IN
    Answers
        www.ua.pt: type A, class IN, addr 193.136.173.25
    Authoritative nameservers
        ua.pt: type NS, class IN, ns ns2.ua.pt
        ua.pt: type NS, class IN, ns ns.ua.pt
    Additional records
        ns.ua.pt: type A, class IN, addr 193.136.172.18
        ns2.ua.pt: type A, class IN, addr 213.228.152.1
```

Iterative (Non-Recursive) Resolution



Recursive Resolution



Iterative vs. Recursive Resolution

- Iterative resolution:
  - Less efficient: increases the average time between a DNS query and its response.
  - Server loads are lower: each server responds immediately to a query,
    - Do not have to store any temporary information,
    - Do nor perform any interaction with other DNS servers.
- Recursive resolution:
  - More efficient: minimizes the average time between a DNS query and its response.
  - Higher server loads: each server must simultaneously manage the state of multiple DNS queries.
    - More memory, more CPU.
    - Not a problem with current servers.

Zone Configuration

- A zone is defined by
  - A zone declaration, which holds the type of the zone, a pointer to the zone file and type specif configuration statements (optional).
  - A zone file, which holds the DNS resource records for all of the domain names associated with the zone.
- Zone files store all of the data served by a DNS server.
- The basic format of the zone file is a time to live (TTL) field followed by the Start Of Authority (SOA) records.
  - The overall TTL instructs non-authoritative DNS servers how long to cache records retrieved from the zone file.
    - With large values it will take more time to propagate changes.
    - With smaller value, the DNS server load will increase (non-authoritative servers will have to send the same requests more frequently).
    - Typical values: 1 hour to a 1 day.
  - The SOA record defines the zone name, an e-mail contact and various time and refresh values applicable to the zone.

Zone Types

- Master: The server reads the zone data direct from local storage (a zone file) and provides authoritative answers for the zone.
- Slave: A slave zone is a replica of the master zone and obtains its zone data by zone transfer operations.
  - The slave will respond authoritatively for the zone as long as it has valid (not timed out) zone data.
- Forward: A zone of type forward is simply a way to configure forwarding on a per-domain or per zone basis.
  - To be effective both a forward and forwarders statement should be included.
- Stub: A stub zone is similar to a slave zone except that it replicates only the NS records of a master zone instead of the entire zone.
- Delegation-only: Indicates only referrals (or delegations) will be issued for the zone and should used for TLDs only not leaf (non TLD) zones.

BIND – Zone Declaration Examples

```
zone "domain.com" {
        type master;
        file "zones/domain.com";
};

zone "200.136.193.in-addr.arpa" {
        type master;
        file "zones/193.136.200";
};

zone "example.com" in {
    type slave;
    file "slave.example.com";
    masters {192.168.2.7; 10.2.3.15 port 1127; 2001:db8:0:1::15;};
};
```

Zone Files

- Zone files contain Resource Records that describe a domain or sub-domain.
  - Format of zone files is an IETF standard defined by RFC 1035.
- Contents
  - Data that indicates the top of the zone and some of its general properties,
    - A SOA Record.
  - Authoritative data for all nodes or hosts within the zone,
    - A (IPv4) or AAAA (IPv6) Records.
  - Data that describes global information for the zone
    - Mail MX Records and Name Server NS Records.
  - In the case of sub-domain delegation the name servers responsible for this sub-domain
    - One or more NS Records.
    - One or more A or AAAA Records

Name Server Records

- SOA (RFC 1035): Start of Authority. Defines the zone name, an e-mail contact and various time and refresh values applicable to the zone.
- A (RFC 1035): IPv4 Address record. An IPv4 address for a host.
- AAAA (RFC 3596): IPv6 Address record. An IPv6 address for a host.
- NS (RFC 1035): Name Server. Defines the authoritative name server(s) for the domain (defined by the SOA record).
- MX (RFC 1035) Mail Exchanger. A preference value and the host name for a mail server/exchanger.
- CNAME (RFC 1035): Canonical Name. An alias name for a host.
- PTR (RFC 1035): IP address (IPv4 or IPv6) to host. Used in reverse maps.
- TXT (RFC 1035): Text information associated with a name.

SOA Record (1)

- @ - represents the base domain
- IN - class of the zome (INternet)
- SOA - record identifier
- The master DNS server for the zone
  - The host where the file was created (nameserver.domain.com)
- Contact e-mail - The e-mail address of the person responsible for administering the domain's zone file.
  - "." is used instead of an "@" in the e-mail name
  - adm.domain.com <=> adm@domain.com email

```
@   IN   SOA     nameserver.domain.com.   adm.domain.com. (
                                          1              ; serial number
                                          3600           ; refresh    [1h]
                                          600            ; retry      [10m]
                                          86400          ; expire     [1d]
                                          3600 )         ; min TTL    [1h]
```

SOA Record (2)

- Serial number - The revision number of this zone file.
  - Increment this number each time the zone file is changed.
  - It is important to increment this value each time a change is made, so that the changes will be distributed to any secondary DNS servers.
- Refresh Time - The time, in seconds, a secondary DNS server waits before querying the primary DNS server's SOA record to check for changes.
  - When the refresh time expires, the secondary DNS server requests a copy of the current SOA record from the primary.
  - The secondary DNS server compares the serial number of the primary DNS server's current SOA record and the serial number in it's own SOA record. If they are different, the secondary DNS server will request a zone transfer from the primary DNS server.
  - The default value is 3,600.
- Retry time - The time, in seconds, a secondary server waits before retrying a failed zone transfer.
  - Usually, the retry time is less than the refresh time. The default value is 600.
- Expire time - The time, in seconds, that a secondary server will keep trying to complete a zone transfer.
  - If this time expires prior to a successful zone transfer, the secondary server will expire its zone file (stops answering queries).
  - The default value is 86,400.
- Negative caching TTL – the time, in seconds, a negative answers (such as when a requested record does not exist) can be cached on non-authoritative servers.
  - This field acts like the overall TTL but specifically for negative answers.
  - Small values are appropriate (15m to 2h).

```
@   IN   SOA     nameserver.domain.com.   adm.domain.com. (
                                          1             ; serial number
                                          3600          ; refresh    [1h]
                                          600           ; retry      [10m]
                                          86400         ; expire     [1d]
                                          3600 )        ; min TTL    [1h]
```

Other Records (1)

- IPv4 Address Record (A)
  - Syntax: "*name ttl class rr ipv4*"

```
; zone fragment for example.com
$TTL 2d ; zone default = 2 days or 172800 seconds
joe         IN      A       192.168.0.3  ; joe & www = same ip
www         IN      A       192.168.0.3
www.example.com.    A       192.168.0.3
fred  3600 IN       A       192.168.0.4  ; TTL overrides $TTL default
ftp         IN      A       192.168.0.24 ; round robin with next
            IN      A       192.168.0.7
mail        IN      A       192.168.0.15  ; mail = round robin
mail        IN      A       192.168.0.32
mail        IN      A       192.168.0.3
```

- IPv6 Address Record (AAAA)
  - Syntax: "*name ttl class rr ipv6*"

```
; zone fragment for example.com
$TTL 2d ; zone default = 2 days or 172800 seconds
$ORIGIN example.com.
joe         IN      AAAA      2001:db8::3  ; joe & www = same ip
www         IN      AAAA      2001:db8::3
; functionally the same as the record above
www.example.com.    AAAA      2001:db8::3
fred  3600 IN       AAAA      2001:db8::4  ; TTL overrides $TTL default
ftp         IN      AAAA      2001:db8::5 ; round robin with next
            IN      AAAA      2001:db8::6
squat       IN      AAAA      2001:db8:0:0:1::13  ; address in another subnet
```

Other Records (2)

- Name Server Record (NS)
  - Syntax: "*name ttl class rr name*"

```
                IN      NS      ns1   ; unqualified name
; the line above is functionally the same as the line below
; example.com. IN      NS      ns1.example.com.
; at least two name servers must be defined
                IN      NS      ns2
; the in-zone name server(s) have an A record
ns1             IN      A       192.168.0.3
ns2             IN      A       192.168.0.3
```

- Mail Exchange Record (MX)
  - Syntax*: "name ttl class rr pref name*"
  - The pref (Preference) field is relative to any other MX record for the zone (value 0 to 65535). Low values are more preferred.

```
                IN      MX      10  mail   ; short form
; the line above is functionally the same as the line below
; example.com. IN      MX      10  mail.example.com.
; any number of mail servers may be defined
                IN      MX      20  mail2.example.com.
; use an external back-up
                IN      MX      30  mail.example.net.
; the local mail server(s) need an A record
mail            IN      A       192.168.0.3
mail2           IN      A       192.168.0.3
```

Other Records (3)

- Canonical Name Record (CNAME)
  - Syntax: "*name ttl class rr canonical_name*"

```
; zone fragment for example.com
$TTL 2d ; zone default = 2 days or 172800 seconds
$ORIGIN example.com.
....
server1     IN      A       192.168.0.3
www         IN      CNAME   server1
ftp         IN      CNAME   server1
```

  - Do not use CNAME records with NS and MX records,
    - Usually it works, but is theoretically not permitted!

Wrong!

```
            IN      MX  10  mail.example.com.
mail        IN      CNAME   server1
server1     IN      A       192.168.0.3
```

Correct!

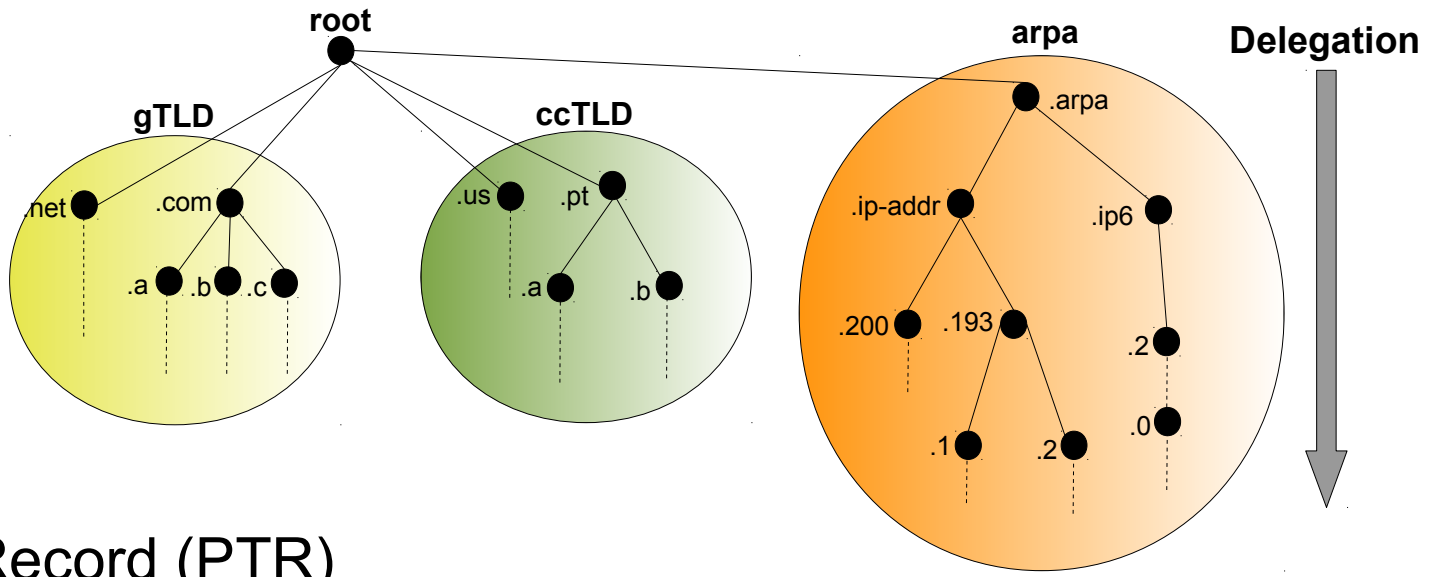
```
            IN      MX  10  mail.example.com.
server1     IN      CNAME   mail
mail        IN      A       192.168.0.3
```

Example

```
$ORIGIN teste.com.
@       IN      SOA     teste.com. adm.teste.com. (
                        199609206       ; serial, todays date + todays serial #
                        8H              ; refresh, seconds
                        2H              ; retry, seconds
                        4W              ; expire, seconds
                        1D )            ; minimum, seconds
                NS      ns1.teste.com.
                NS      ns2.teste.com.
                MX      10 teste.com.   ; Primary Mail Exchanger
                TXT     "TESTE Corp"

localhost       A       127.0.0.1
router          A       206.6.177.1
teste.com.      A       206.6.177.2
ns1             A       206.6.177.3
ns2             A       206.6.177.4
www             A       207.159.141.192

ftp             CNAME   teste.com.
mail            CNAME   teste.com.
news            CNAME   teste.com.

funn            A       206.6.177.2

;       Workstations
ws-177200       A       206.6.177.200
ws-177201       A       206.6.177.201
```

Reverse DNS

- In order to perform Reverse Resolution using normal recursive and Iterative queries the DNS designers defined a special (reserved) Domain Name called:
  - IN-ADDR.ARPA for IPv4 addresses,
    - Resolves <reversed_(partial)_IPv4_Address>.in-addr.arpa
  - IP6.ARPA for IPv6 addresses.
    - Resolves <reversed_(partial)_IPv6_Address>.ip6.arpa



- Uses the Pointer Record (PTR)
  - Pointer records are the opposite of A and AAAA.
    - Syntax: “name *ttl class rr name*”

IPv4 Reverse DNS - Example

```
zone "200.136.193.in-addr.arpa" {
        type master;
        file "zones/193.136.200";
};
```

```
$TTL 3D
@               IN      SOA     land-5.com. root.land-5.com. (
                                199609206       ; Serial
                                28800   ; Refresh
                                7200    ; Retry
                                604800  ; Expire
                                86400)  ; Minimum TTL
                        NS      land-5.com.
                        NS      ns2.psi.net.
;       Servers
1       PTR     router.land-5.com.
2       PTR     land-5.com.
2       PTR     funn.land-5.com.

;       Workstations

200     PTR     ws-177200.land-5.com.
201     PTR     ws-177201.land-5.com.
202     PTR     ws-177202.land-5.com.
203     PTR     ws-177203.land-5.com.
```

IPv6 Reverse DNS – Example

```
$TTL 2d    ; default TTL for zone 172800 secs
$ORIGIN 0.0.0.0.8.b.d.0.1.0.0.2.IP6.ARPA.
@          IN      SOA   ns1.example.com. hostmaster.example.com. (
                         2003080800 ; sn = serial number
                         12h         ; refresh = refresh
                         15m        ; retry = update retry
                         3w         ; expiry = expiry
                         2h         ; min = minimum
                         )
; name servers Resource Recordsfor the domain
          IN      NS      ns1.example.com.
; the second name servers is
; external to this zone (domain).
          IN      NS      ns2.example.net.
; PTR RR maps a IPv6 address to a host name
; hosts in subnet ID 1
1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0          IN      PTR     ns1.example.com.
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0          IN      PTR     mail.example.com.
; hosts in subnet ID 2
1.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.2.0.0.0          IN      PTR     joe.example.com.
2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.2.0.0.0          IN      PTR     www.example.com.
```