



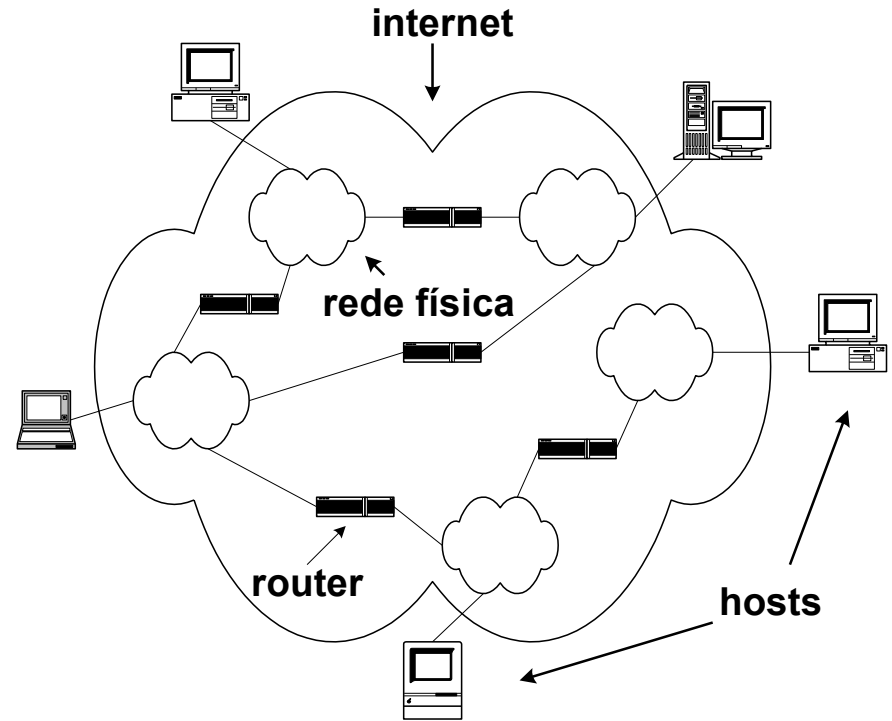
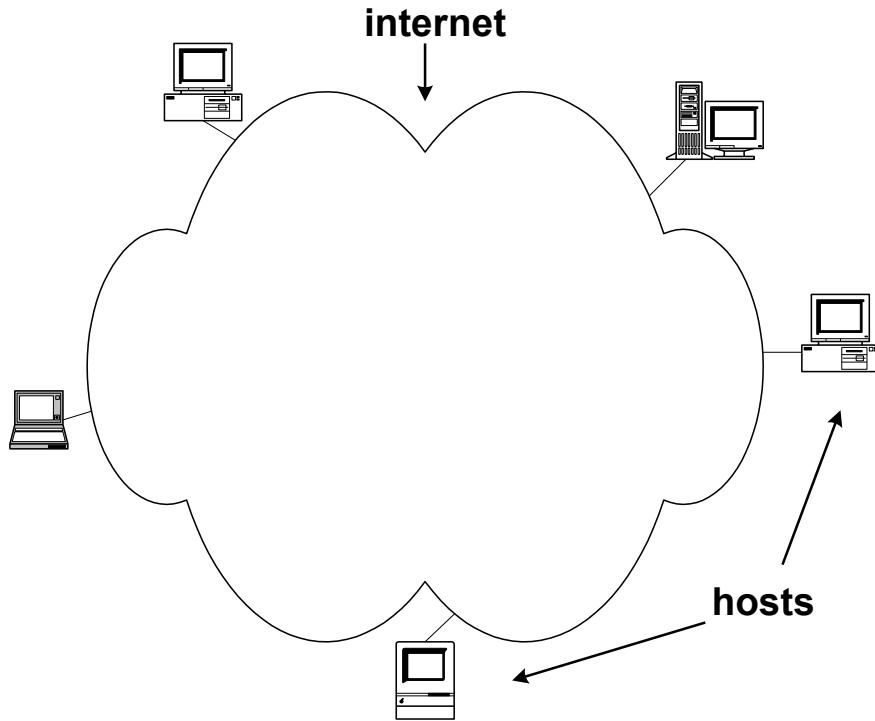
universidade de aveiro
theoria poiesis praxis

Introdução às Redes IP

Redes de Comunicações 1

**Licenciatura em Engenharia de Computadores e
Informática
DETI-UA**

A Internet



Internet: História

Data	Evento
1960	Proposta para uma rede militar à prova de bombas.
1969	Advanced Research Project Agency (ARPA) financia ID em redes distribuídas
1972	ARPANET: primeiro email
1973	UK e Noruega ligam-se à ARPANET
1974	Primeira versão do Transmission Control Protocol (TCP)
1983	TCP Internet Protocol (TCP/IP) aceite como standard
1984	DNS introduzido
1990	ARPANET torna-se em INTERNET
1992	Central European Research Network (CERN) cria a norma de hipertexto (HTML): surgimento da Word Wide Web (WWW).
1993	Mosaic, seguida pelo Netscape, tornam-se as ferramentas habituais na Internet
1996	Comunicação multimédia vulgarizada

Internet: História

Data	Evento
1997	Netflix: vender DVDs por correio
1998	Google
1998	IPv6
1999	Peer-2-peer com Napster (música)
2004	Facebook
2005	Youtube.com
2006	Twitter
2010	Pinterest e Instagram
2016	Google assistant (ativação voz)
2018	IoT (7M dispositivos)
2019	5G
2021	4.66B pessoas ligadas à Internet (mais de metade da população global)
2022	Satélites LEO (Low-Orbit) - Starlink

Rede daqui até... (2021)

China

```
C:\Users\Susana>tracert www.zju.edu.cn
```

```
Tracing route to www.zju.edu.cn [61.164.42.190]  
over a maximum of 30 hops:
```

```
 1      3 ms      3 ms      1 ms  staff-4062.wireless.ua.pt [192.168.31.253]  
 2      3 ms      2 ms      2 ms  10.1.0.6  
 3      3 ms      4 ms      6 ms  193.137.173.243  
 4      8 ms     12 ms      7 ms  Router2.Campanha.fccn.pt [193.136.4.26]  
 5      9 ms     14 ms     23 ms  Router3.10GE.DWDM.Lisboa.fccn.pt [193.136.1.1]  
 6     22 ms     18 ms     18 ms  ROUTER4.10GE.CR2.Lisboa.fccn.pt [193.137.0.20]  
 7     10 ms      9 ms      7 ms  fccn.mx2.lis.pt.geant.net [62.40.124.4]  
 8     25 ms     20 ms     19 ms  xe-2-3-0.rt1.mad.es.geant.net [62.40.124.5]  
 9    111 ms     66 ms     42 ms  xe-2-0-0.mx1.gen.ch.geant.net [62.40.124.6]  
10     49 ms     49 ms     47 ms  ae1.mx1.fra.de.gn.net [62.40.124.7]  
11     49 ms      *     103 ms  xe-8-0-1.edge5.Fra.de.gn.net [62.40.124.8]
```

```
C:\Users\Susana>tracert -4 www.zju.edu.cn
```

```
Tracing route to www.zju.edu.cn.queniusa.com [163.181.50.229]  
over a maximum of 30 hops:
```

```
 1      2 ms      6 ms      8 ms  GEN8 [192.168.1.254]  
 2      *      *      *      Request timed out.  
 3      *      *      8 ms  telepac16-hsi.cprm.net [195.8.30.250]  
 4     22 ms     6 ms     9 ms  tva-cr1-be10-200.cprm.net [195.8.30.249]  
 5     24 ms     19 ms    15 ms  lis2-cr1-be5.cprm.net [195.8.0.153]  
 6     32 ms     15 ms    13 ms  ae19.lisbona1.lis.seabone.net [213.144.187.236]  
 7     49 ms     45 ms    59 ms  ae10.milano58.mil.seabone.net [195.22.208.117]  
 8     47 ms      *      *      Request timed out.il.seabone.net [93.186.128.78]  
 9     46 ms     45 ms    44 ms  163.181.50.229  
10      *      *      *      Request timed out.  
11      *      *      *      Request timed out.  
12     471 ms     *     486 ms  61.164.5.62  
13     441 ms     442 ms    449 ms  61.164.4.54  
14     477 ms     442 ms    480 ms  115.236.178.234  
15     447 ms     448 ms    447 ms  61.164.42.190
```

```
Trace complete.
```

Austrália

```
C:\Users\Susana>tracert www.adelaide.edu.au
```

```
Tracing route to online-media.adelaide.edu.au [129.127.144.141]  
over a maximum of 30 hops:
```

```
 1      7 ms      8 ms     12 ms  staff-4063.wireless.ua.pt [192.168.31.253]  
 2     15 ms      6 ms     10 ms  10.1.0.6  
 3     14 ms     18 ms     13 ms  193.137.173.243  
 4     28 ms     14 ms     12 ms  Router2.Campanha.fccn.pt [193.136.4.26]  
 5     38 ms     13 ms     16 ms  Router3.10GE.DWDM.Lisboa.fccn.pt [193.136.1.1]  
 6     12 ms     10 ms     196 ms  ROUTER4.10GE.CR2.Lisboa.fccn.pt [193.137.0.20]
```

<http://hostip.info/>

Rede daqui até... (2021->2024)

```
C:\Users\Susana>tracert www.zju.edu.cn

Tracing route to www.zju.edu.cn [61.164.42.190]
over a maximum of 30 hops:
  0  1    3 ms    3 ms    1 ms  staff-4062.wireless.ua.pt [192.168.31.252]
  1  2    3 ms    2 ms    2 ms  10.1.0.6
  2  3    3 ms    4 ms    6 ms  193.137.173.243
  3  4    8 ms   12 ms    7 ms  Router2.Campanha.fccn.pt [193.136.4.261]
  4  5    9 ms   14 ms   23 ms  Router3.10GE.DWDM.Lisboa.fccn.pt [193.136.1.11]
  5  6   22 ms   18 ms   18 ms  ROUTER4.10GE.CR2.Lisboa.fccn.pt [193.137.0.201]
  6  7   10 ms    9 ms    7 ms  fccn.mx2.lis.pt.geant.net [193.137.0.201]
  7  8   25 ms   20 ms   19 ms  xe-2-3-0.rt1.mad
  8  9  111 ms   66 ms   42 ms  xe-2-0-0.mx1.gen
  9 10   49 ms   49 ms   47 ms  ae1.mx1.fra.de.g
 10 11   49 ms    *   103 ms  xe-8-0-1.edge5.F
11 12  193 ms  195 ms  228 ms  vlan60.csw1.Fran
12 13  196 ms  194 ms  257 ms  ae-62-62.ebr2.Fr
13 14  206 ms  249 ms  234 ms  ae-22-22.ebr2.Lo
14 15  194 ms  229 ms  196 ms  ae-44-44.ebr1.Ne
15 16  201 ms  196 ms  193 ms  ae-91-91.csw4.Ne
16 17  197 ms  208 ms  198 ms  ae-92-92.ebr2.Ne
17 18  196 ms  196 ms  194 ms  ae-2-2.ebr1.SanJ
18 19  195 ms  195 ms  195 ms  ae-81-81.csw3.Sa
19 20  198 ms  194 ms  194 ms  ae-3-80.edge2.Sa
20 21    *   201 ms  198 ms  CHINA-TELEC.edge
21 22  196 ms  200 ms  202 ms  202.97.51.9
22 23  396 ms  399 ms  406 ms  202.97.50.89
23 24  426 ms  424 ms  418 ms  202.97.33.121
24 25  494 ms  469 ms  464 ms  202.97.33.13
25 26    *    *    *    Request timed out.
26 27  471 ms    *   486 ms  61.164.5.62
27 28  441 ms  442 ms  449 ms  61.164.4.54
28 29  477 ms  442 ms  480 ms  115.236.178.234
29 30  447 ms  448 ms  447 ms  61.164.42.190

Trace complete.

C:\Users\user>tracert -4 www.zju.edu.cn

Tracing route to www.zju.edu.cn.queniusa.com [163.181.50.229]
over a maximum of 30 hops:
  0  1    2 ms    6 ms    8 ms  GEN8 [192.168.1.254]
  1  2    *    *    *    Request timed out.
  2  3    *    *    8 ms  telepac16-hsi.cprm.net [195.8.30.250]
  3  4   22 ms    6 ms    9 ms  tva-cr1-be10-200.cprm.net [195.8.30.249]
  4  5   24 ms   19 ms   15 ms  lis2-cr1-be5.cprm.net [195.8.0.153]
  5  6   32 ms   15 ms   13 ms  ae19.lisbona1.lis.seabone.net [213.144.187.236]
  6  7   49 ms   45 ms   59 ms  ae10.milano58.mil.seabone.net [195.22.208.117]
  7  8   47 ms    *    *    Request timed out.il.seabone.net [93.186.128.78]
  8  9   46 ms   45 ms   44 ms  163.181.50.229
  9 10

Trace complete.
```

Rede daqui até... (2021->2024)

```
C:\Users\Susana>tracert www.adelaide.edu.au

Tracing route to online-media.adelaide.edu.au [129.127.144.141]
over a maximum of 30 hops:

  1    7 ms     8 ms     12 ms   staff-4063.wireless.ua.pt [192.168.31.253]
  2   15 ms     6 ms     10 ms   10.1.0.6
  3   14 ms     18 ms     13 ms   193.137.173.243
  4   28 ms     14 ms     12 ms   Router2.Campanha.fccn.pt [193.136.4.26]
  5   38 ms     13 ms     16 ms   Router3.10GE.DWDM.Lisboa.fccn.pt [193.136.1.1]
  6   12 ms     10 ms    196 ms   ROUTER4.10GE.CR2.Lisboa.fccn.pt [193.137.0.20]
  7   15 ms     23 ms     29 ms   fccn.mx2.lis.pt.geant.net [62.40.124.97]
  8   31 ms     42 ms     38 ms   xe-2-3-0.rt1.mad.es.geant.net [62.40.98.107]
  9  173 ms    212 ms    146 ms   mb-so-02-v4.bb.tein3.net [202.179.249.117]
 10  190 ms    194 ms    198 ms   sg-so-04-v4.bb.tein3.net [202.179.249.53]
 11  194 ms    199 ms    198 ms   au-pr-v4.bb.tein3.net [202.179.249.62]
 12  412 ms    337 ms    340 ms   so-4-1-0.bb1.b.syd.aarnet.net.au [202.158.194.24]
 13  339 ms    363 ms    340 ms   so-0-1-0.bb1.b.cbr.aarnet.net.au [202.158.194.30]
 14  342 ms    395 ms    341 ms   ge-0-0-0.bb1.a.cbr.aarnet.net.au [202.158.194.20]
 15  351 ms    349 ms    351 ms   so-0-1-0.bb1.b.mel.aarnet.net.au [202.158.194.42]
 16  348 ms    347 ms    347 ms   ge-0-0-0.bb1.a.mel.aarnet.net.au [202.158.194.18]
 17   *         358 ms    355 ms   so-2-0-0.bb1.a.adl.aarnet.net.au [202.158.194.17]
 18  363 ms    356 ms    357 ms   xe-0-0-0.er2.adelaide.cpe.aarnet.net.au [202.158.199.42]
 19  357 ms    354 ms    382 ms   gw2.er2.adelaide.cpe.aarnet.net.au [202.158.199.114]
 20   *         *         *       Request timed out.
 21   *         *         *       Request timed out.
 22   *         *         *       Request timed out.
 23  361 ms    353 ms    359 ms   online-media.adelaide.edu.au [129.127.144.141]

Trace complete.
```

```
>tracert -4 www.adelaide.edu.au

Tracing route to online-media.adelaide.edu.au [129.127.149.1]
over a maximum of 30 hops:

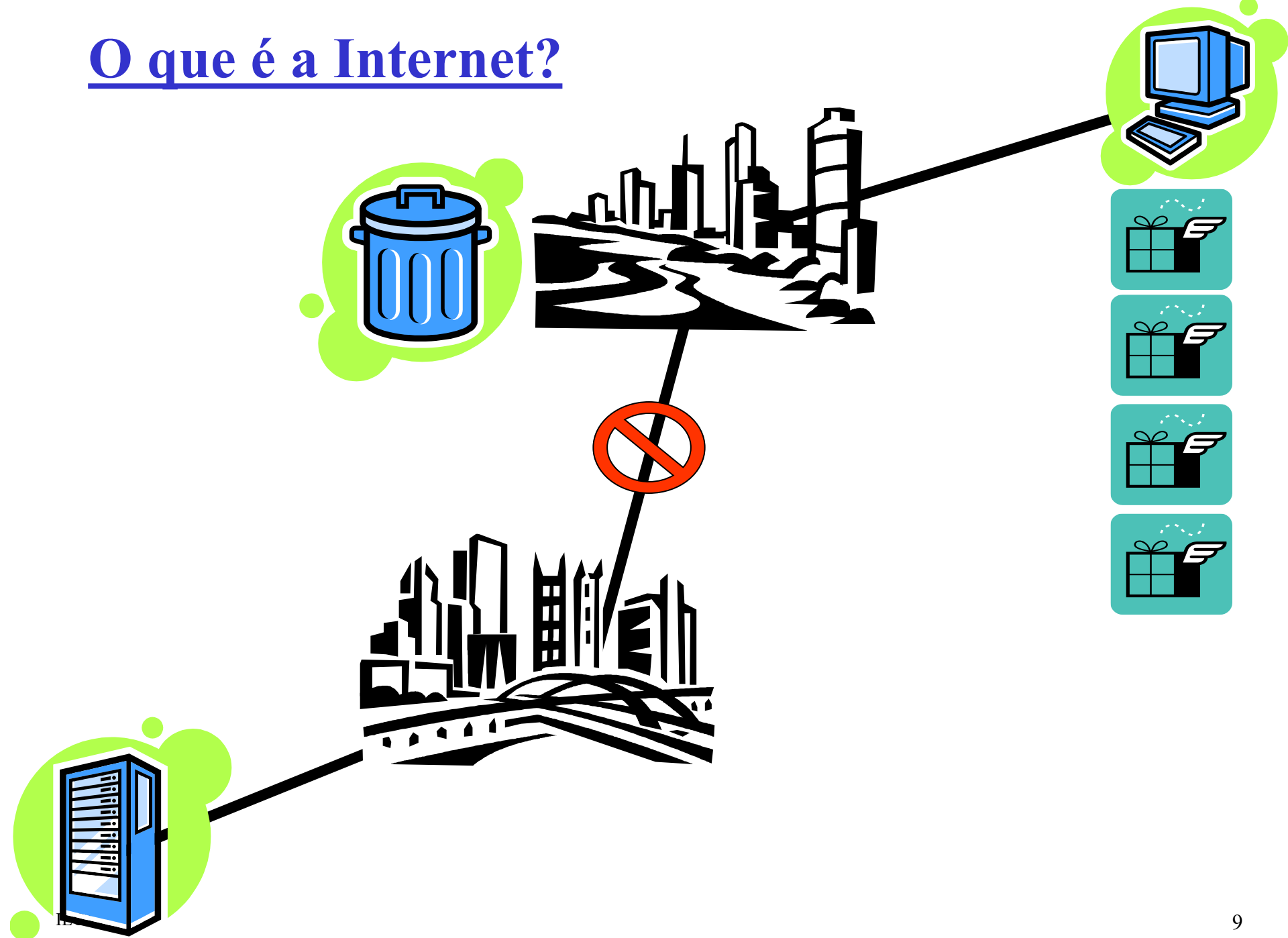
  0 ms     7 ms    GEN8 [192.168.1.254]
  *         *       Request timed out.
  7 ms     7 ms   telepac15-hsi.cprm.net [195.8.30.246]
 29 ms    15 ms   ga-cr1-be10-200.cprm.net [195.8.30.245]
 32 ms    24 ms   lis2-cr1-be4.cprm.net [195.8.1.57]
 12 ms    13 ms   ae19.lisbona1.lis.seabone.net [213.144.187.236]
 193 ms   213 ms   ae13.paloalto2.pao.seabone.net [195.22.195.25]
  *         *       Request timed out.
  9  449 ms    357 ms    359 ms   xe-1-2-1.pe2.brwy.nsw.aarnet.net.au [202.158.194.176]
 10  398 ms    354 ms    360 ms   et-2-1-0.pe1.mcqp.nsw.aarnet.net.au [113.197.15.142]
 11  347 ms    367 ms    348 ms   et-0-3-0.pe1.eskp.nsw.aarnet.net.au [113.197.15.3]
 12  372 ms    367 ms    406 ms   et-0-3-0.pe1.prka.sa.aarnet.net.au [113.197.15.42]
 13  376 ms    411 ms    368 ms   adelaide.vlan227.xe-5-1-1.pe1.prka.sa.aarnet.net.au [138.44.192.95]
 14   *         *         *       Request timed out.
 15   *         *         *       Request timed out.
 16   *         *         *       Request timed out.
 17   *         *         *       Request timed out.
 18  379 ms    432 ms    515 ms   online-media.adelaide.edu.au [129.127.149.1]

Trace complete.
```

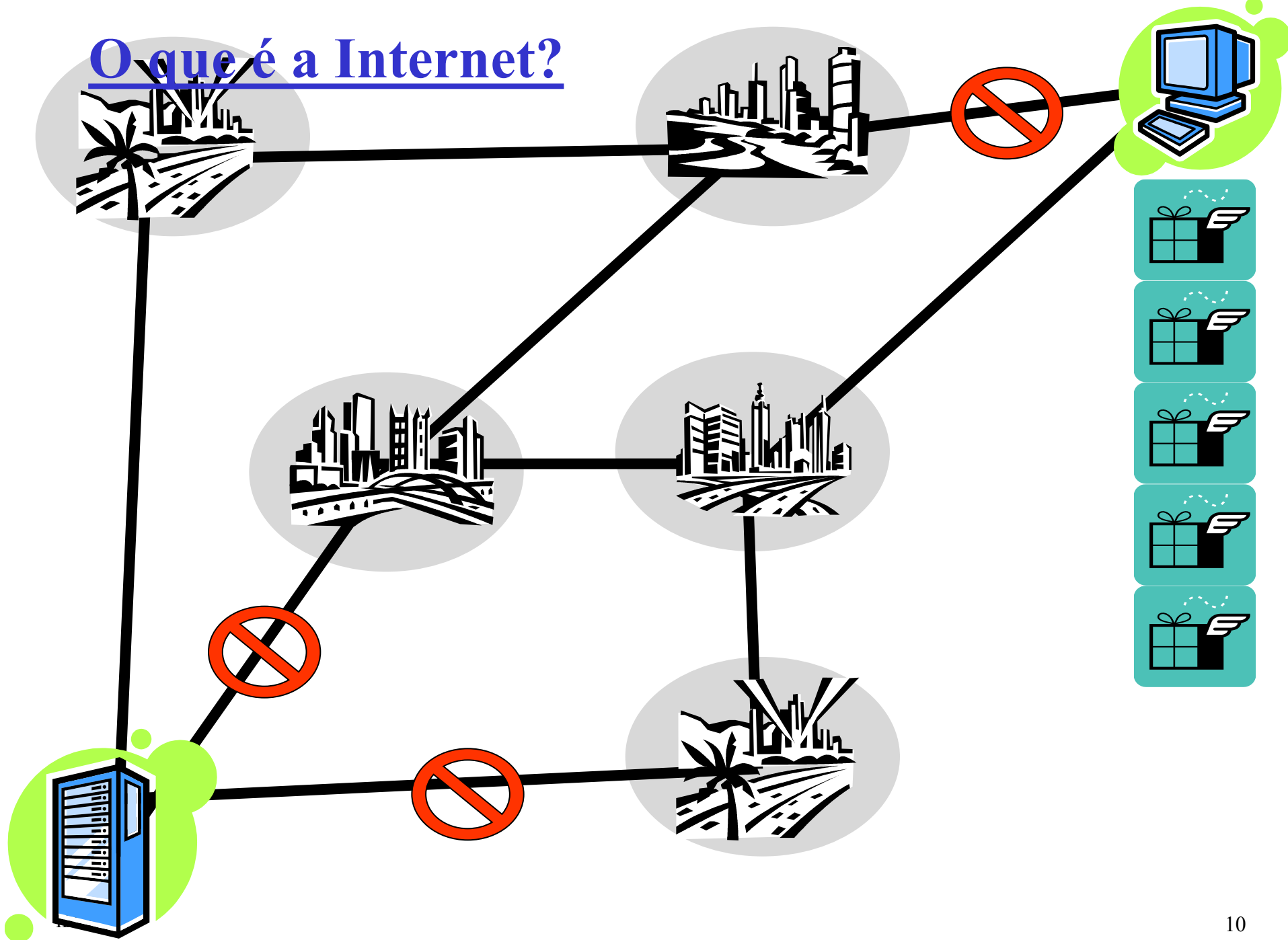
O que é a Internet?



O que é a Internet?



O que é a Internet?



O que é um protocolo?

Protocolos humanos:

- “Que horas são?”
- “Eu tenho uma pergunta!”

... são enviadas mensagens específicas

... são executadas acções específicas quando são recebidas mensagens

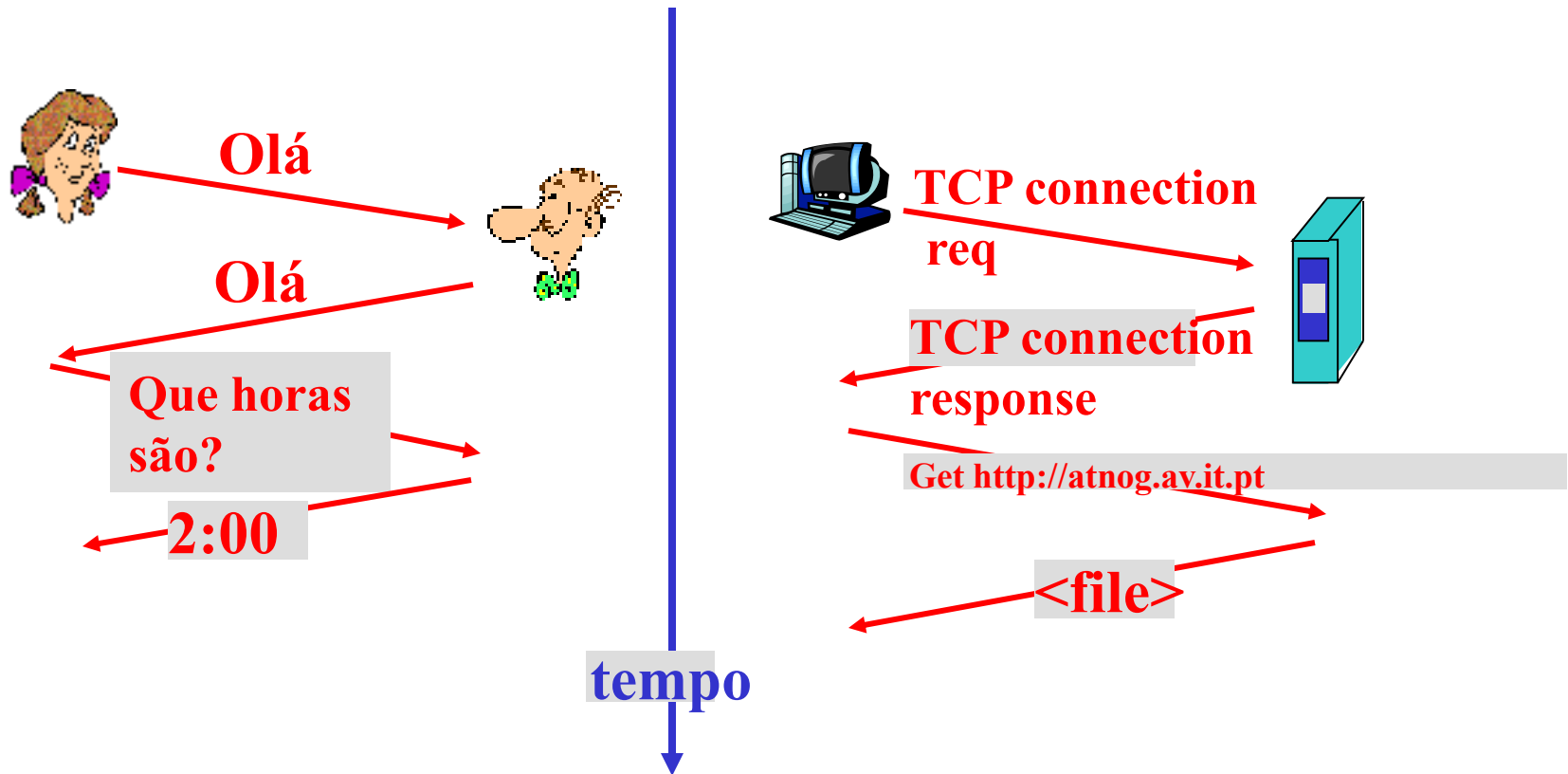
Protocolos de rede:

- Máquinas em vez de humanos
- Todas as comunicações na Internet são executadas por protocolos

Os protocolos definem o formato e a ordem das mensagens enviadas e recebidas entre as entidades da rede, e as acções executadas quando da transmissão e recepção das mensagens

O que é um protocolo?

Um protocolo humano e um protocolo de rede:



Pesquisa de endereço google.com

No.	Time	Source	Destination	Protocol	Length	Info
9	2.07589900	192.168.1.86	192.168.1.254	DNS	74	Standard query 0x8ee8 A www.google.com
10	2.10753300	192.168.1.254	192.168.1.86	DNS	154	Standard query response 0x8ee8 A 173.194.41.211 A 173.194.41.208 A 173.194.41.212 A 173.194.41.203
11	2.11641400	192.168.1.86	173.194.41.211	ICMP	74	Echo (ping) request id=0x0001, seq=26782/40552, ttl=128 (reply in 12)
12	2.14653200	173.194.41.211	192.168.1.86	ICMP	74	Echo (ping) reply id=0x0001, seq=26782/40552, ttl=55 (request in 11)

!!!

Frame 9: 74 bytes on wire (592 bits), 74 bytes captured (592 bits) on interface 0

Ethernet II, Src: IntelCor_d2:2d:87 (88:53:2e:d2:2d:87), Dst: ThomsonsT_86:bc:d3 (08:76:ff:86:bc:d3)

Destination: ThomsonsT_86:bc:d3 (08:76:ff:86:bc:d3)

Source: IntelCor_d2:2d:87 (88:53:2e:d2:2d:87)

Type: IP (0x0800)

Internet Protocol Version 4, Src: 192.168.1.86 (192.168.1.86), Dst: 192.168.1.254 (192.168.1.254)

Version: 4

Header length: 20 bytes

Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))

Total Length: 60

Identification: 0x7f08 (32520)

Flags: 0x00

Fragment offset: 0

Time to live: 128

Protocol: UDP (17)

Header checksum: 0x3704 [correct]

Source: 192.168.1.86 (192.168.1.86)

Destination: 192.168.1.254 (192.168.1.254)

[Source GeoIP: Unknown]

[Destination GeoIP: Unknown]

User Datagram Protocol, Src Port: 62912 (62912), Dst Port: domain (53)

Source port: 62912 (62912)

Destination port: domain (53)

Length: 40

Checksum: 0x6773 [validation disabled]

Domain Name System (query)

```

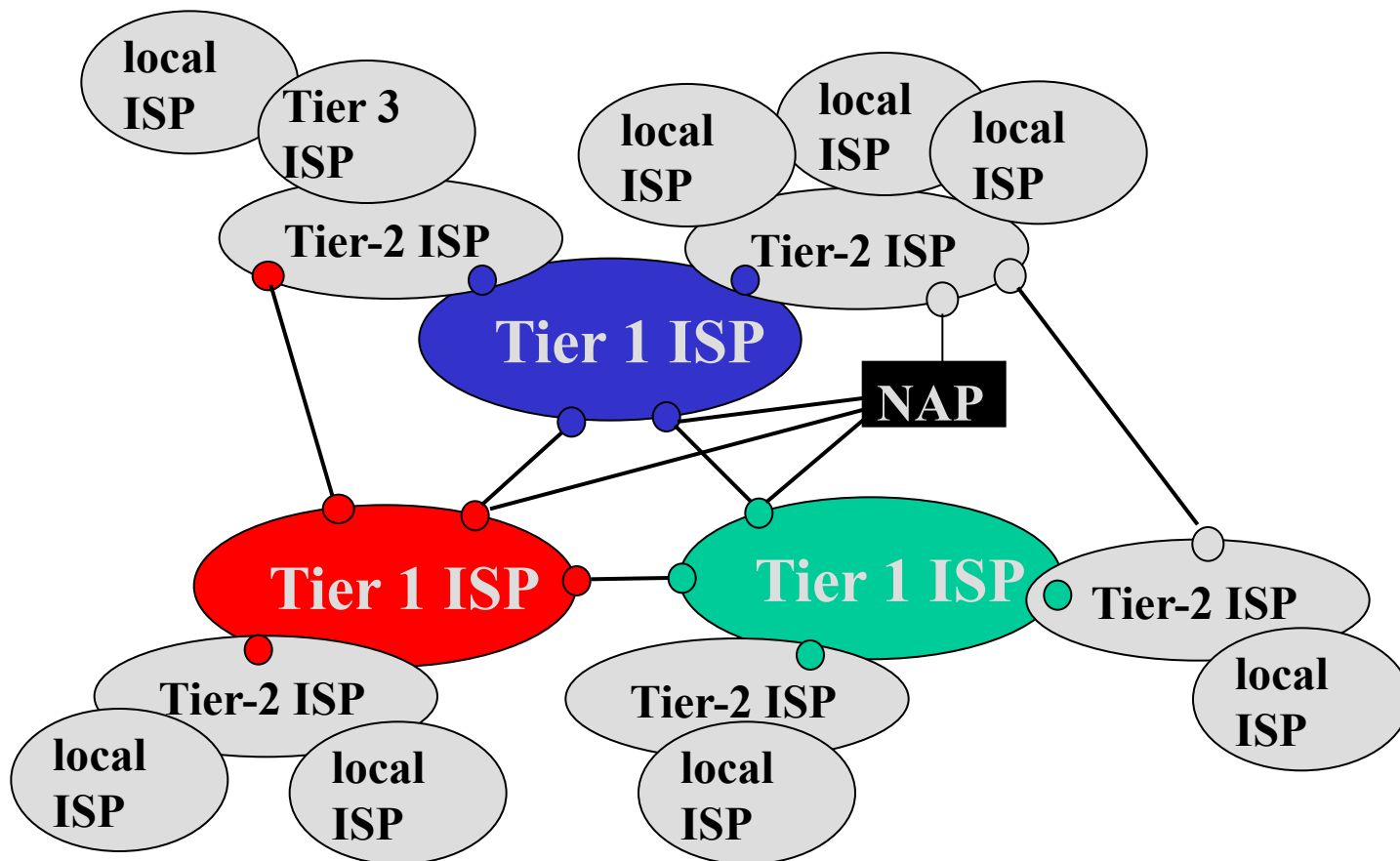
0000  08 76 ff 86 bc d3 88 53 2e d2 2d 87 08 00 45 00  .v.....S ..-...E.
0010  00 3c 7f 08 00 00 80 11 37 04 c0 a8 01 56 c0 a8  .<..... 7...V..
0020  01 fe f5 c0 00 00 35 00 28 67 73 8e e8 01 00 00 01  .....5.( gs.....
0030  00 00 00 00 00 00 00 03 77 77 77 06 67 6f 67 6c  .....w ww.googl
0040  65 03 63 6f 6d 00 00 01 00 01  e.com... ..
  
```

Ping ao google.com

No.	Time	Source	Destination	Protocol	Length	Info
9	2.07589900	192.168.1.86	192.168.1.254	DNS	74	Standard query 0x8ee8 A www.google.com
10	2.10753300	192.168.1.254	192.168.1.86	DNS	154	Standard query response 0x8ee8 A 173.194.41.211 A 173.194.41.208 A 173.194.41.212 A 173.194.41.213
11	2.11641400	192.168.1.86	173.194.41.211	ICMP	74	Echo (ping) request id=0x0001, seq=26782/40552, ttl=128 (reply in 12)
12	2.14653200	173.194.41.211	192.168.1.86	ICMP	74	Echo (ping) reply id=0x0001, seq=26782/40552, ttl=55 (request in 11)
!!!						
Ethernet II, Src: IntelCor_d2:2d:87 (88:53:2e:d2:2d:87), Dst: ThomsonT_86:bc:d3 (08:76:ff:86:bc:d3)						
Destination: ThomsonT_86:bc:d3 (08:76:ff:86:bc:d3)						
Source: IntelCor_d2:2d:87 (88:53:2e:d2:2d:87)						
Type: IP (0x0800)						
Internet Protocol Version 4, Src: 192.168.1.86 (192.168.1.86), Dst: 173.194.41.211 (173.194.41.211)						
Version: 4						
Header length: 20 bytes						
Differentiated Services Field: 0x00 (DSCP 0x00: Default; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))						
Total Length: 60						
Identification: 0x7f09 (32521)						
Flags: 0x00						
Fragment offset: 0						
Time to live: 128						
Protocol: ICMP (1)						
Header checksum: 0x2224 [correct]						
Source: 192.168.1.86 (192.168.1.86)						
Destination: 173.194.41.211 (173.194.41.211)						
[Source GeoIP: Unknown]						
[Destination GeoIP: Unknown]						
Internet Control Message Protocol						
Type: 8 (Echo (ping) request)						
Code: 0						
Checksum: 0xe4bc [correct]						
Identifier (BE): 1 (0x0001)						
Identifier (LE): 256 (0x0100)						
Sequence number (BE): 26782 (0x689e)						
0000	08 76 ff 86 bc d3 88 53	2e d2 2d 87 08 00 45 00	.v.....S ..-...E.			
0010	00 3c 7f 09 00 00 80 01	22 24 c0 a8 01 56 ad c2	.<..... "\$...V..			
0020	29 d3 08 00 e4 bc 00 01	68 9e 61 62 63 64 65 66). h.abcdef			
0030	67 68 69 6a 6b 6c 6d 6e	6f 70 71 72 73 74 75 76	ghijklmn opqrstuv			
0040	77 61 62 63 64 65 66 67	68 69	wabcdefg hi			

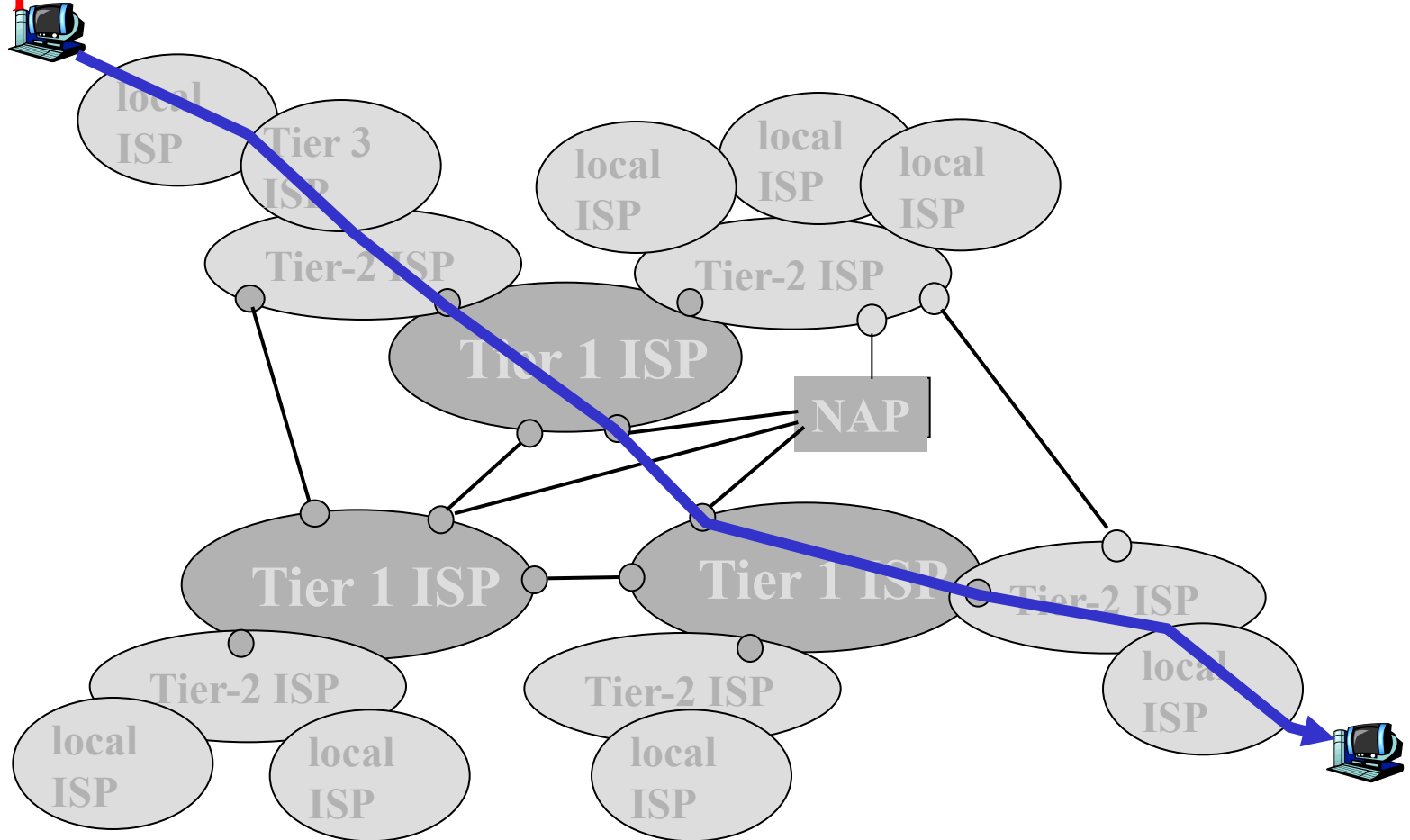
Estrutura da Internet: rede de redes

- Aproximadamente hierárquica
- **ISPs de nível 1** (cobertura nacional/internacional, e.g Sprint e AT&T), **ISPs de nível 2** (mais pequenos, frequentemente regionais), **ISPs de nível 3** e **ISPs locais** (redes de acesso)



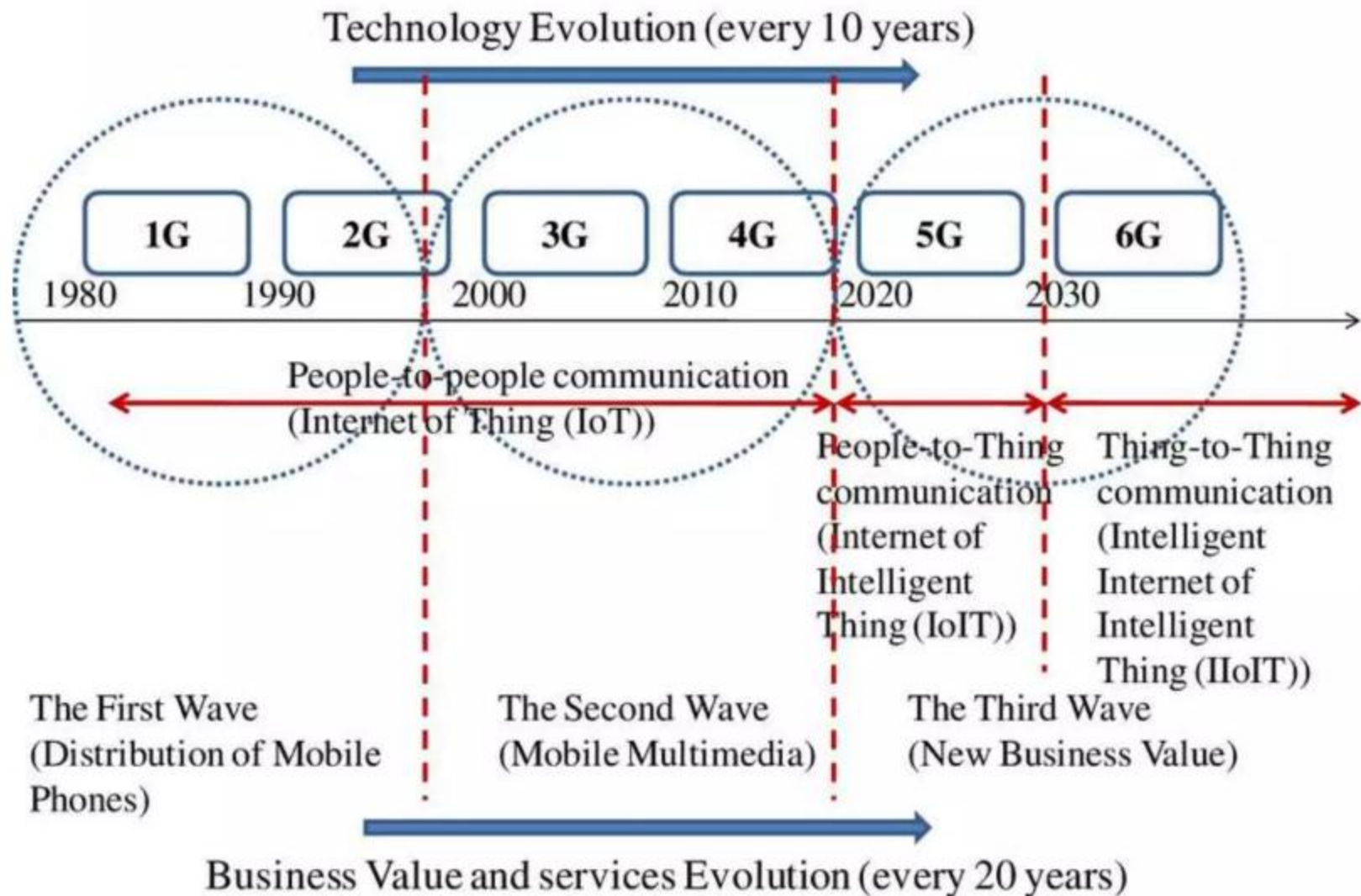
Estrutura da Internet: rede de redes

- Um pacote atravessa muitas redes!

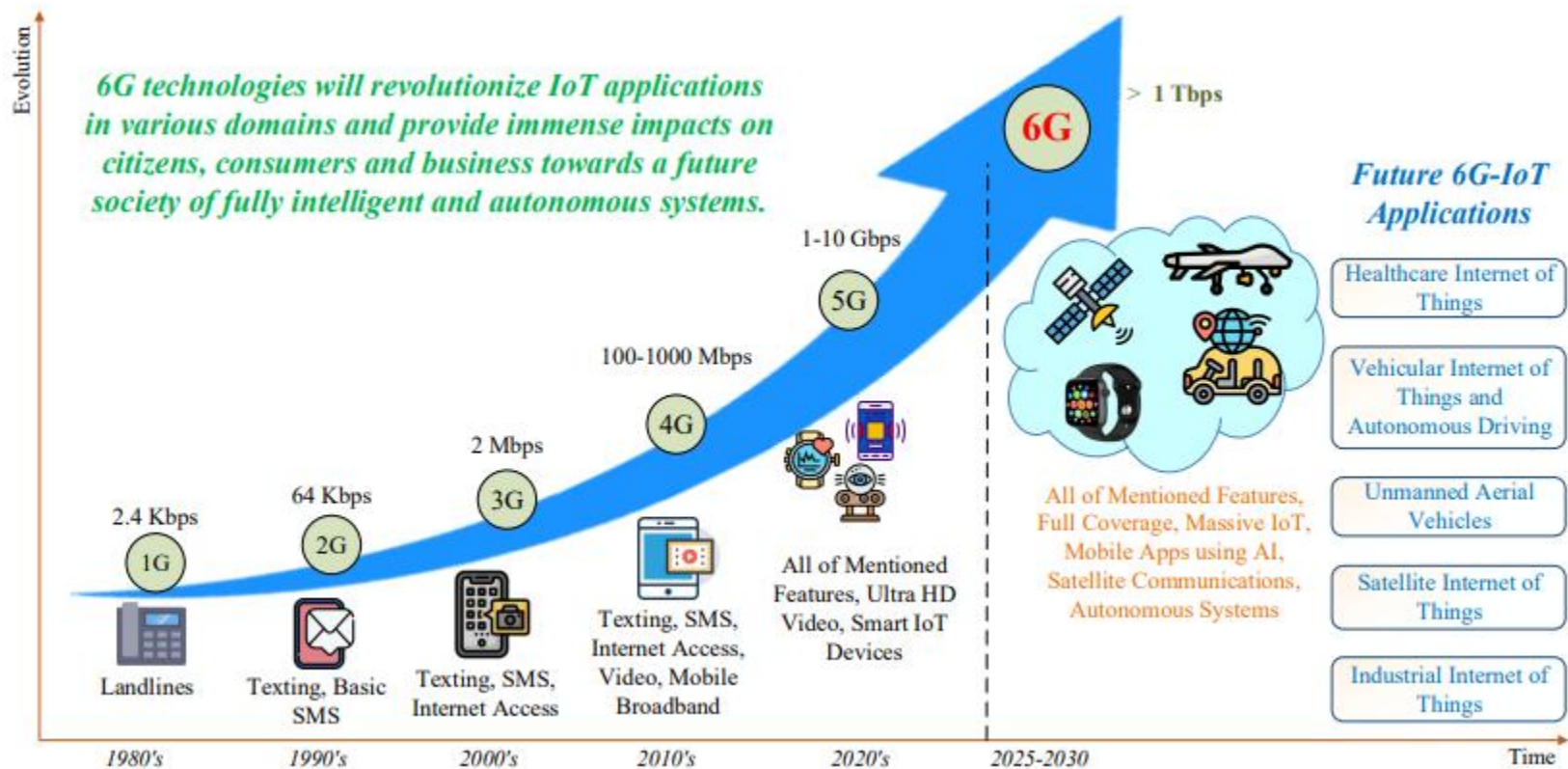


Presente/Futuro

1G para 6G



1G para 6G



O que se espera em 6G

