

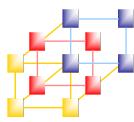
# Unit 1

## 網路程式設計概念



## 大綱

- 網路
- OSI 和 TCP/IP 模型
- 網路位址 (IP)
- 基本概念
- 主從式架構
- 解析網路封包



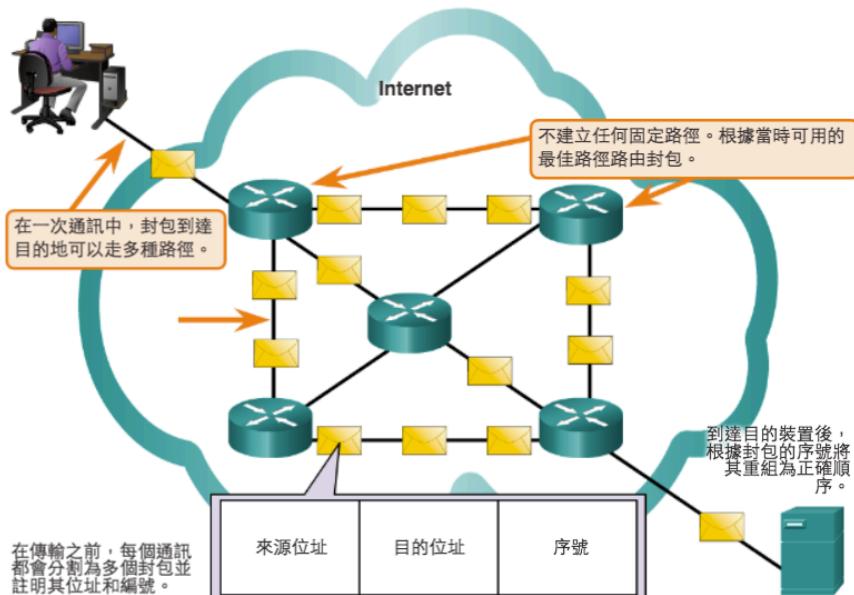
## 網路

- 網路是由網路設備 (Network devices)、電腦主機 (Computers) 及傳輸媒體 (Communication medias) 所共同組合而成，它們彼此之間透過一致的協定 (Protocol) 可以接收、傳送資料
  - 一般我們以節點 (Node) 來表示網路上的任何設備，以主機 (Host) 來表示一般電腦
  - 每一個在網路上的 node 都有一個位址 (Address)
- 目前的網際網路使用封包交換 (Packet-switching) 技術來傳送資料，每一個被傳送的資料都被切割成一個個的片段 (Segment)，再組成封包 (Packet) 傳送

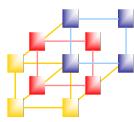


## 封包交換網路

資料網路中的封包交換



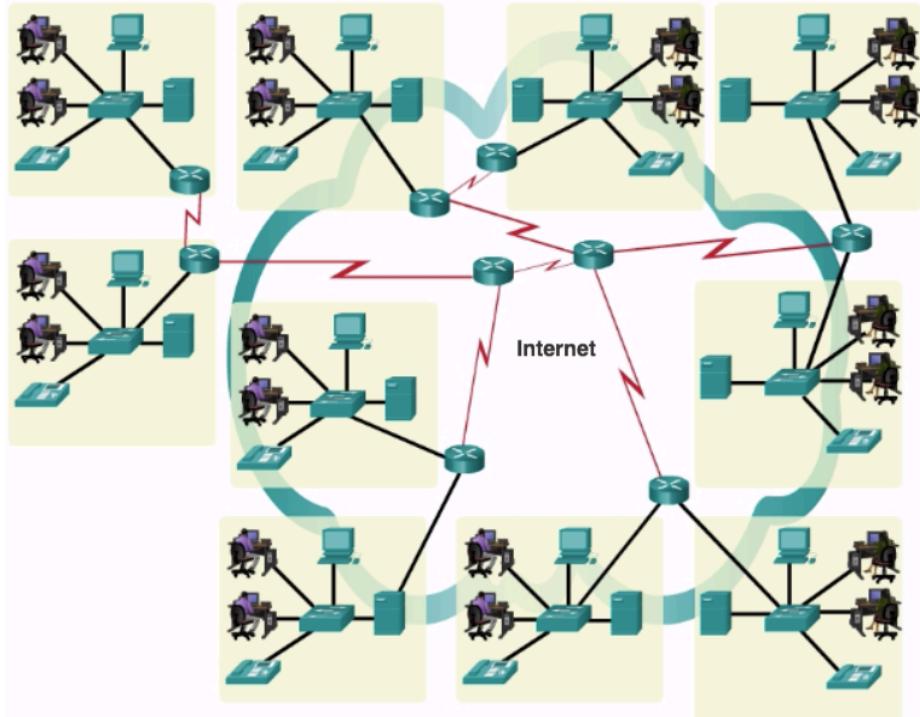
在尖峰期，通訊可能會延遲，但不會被拒絕。



# Internet

Internet 是大量網路的聚合體，並不屬於任何個人或組織

- 採用統一的公認技術和標準
- 眾多網路管理機構相互合作



LAN 和 WAN 可以連接成互連網 *Network Programming*

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# OSI 和 TCP/IP 模型

## OSI 模型

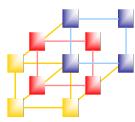


## TCP/IP 模型



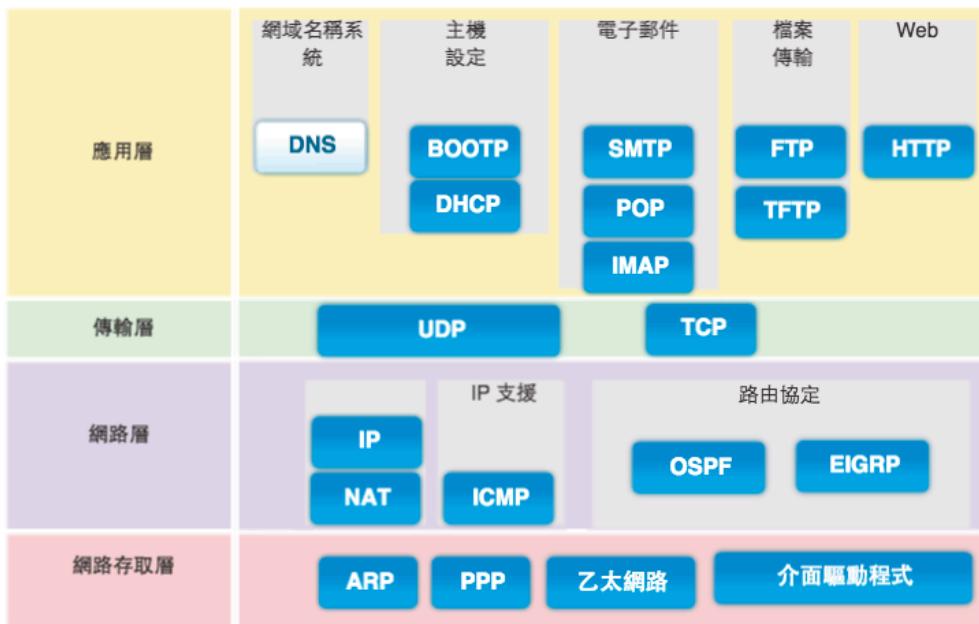
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# TCP/IP 協定套件

TCP/IP 協定套件和通訊程序

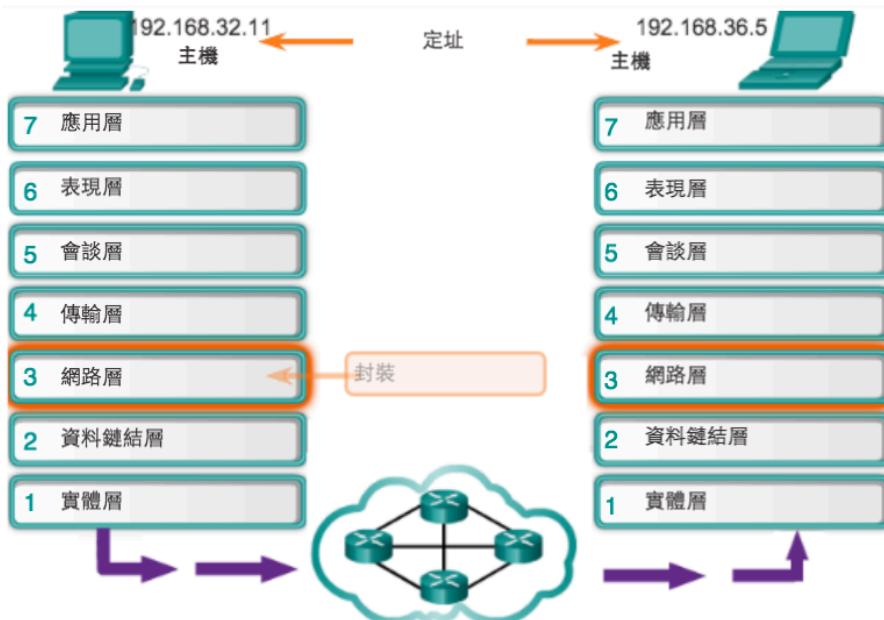


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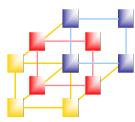
# 網路位址 (IP)



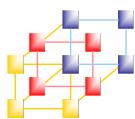
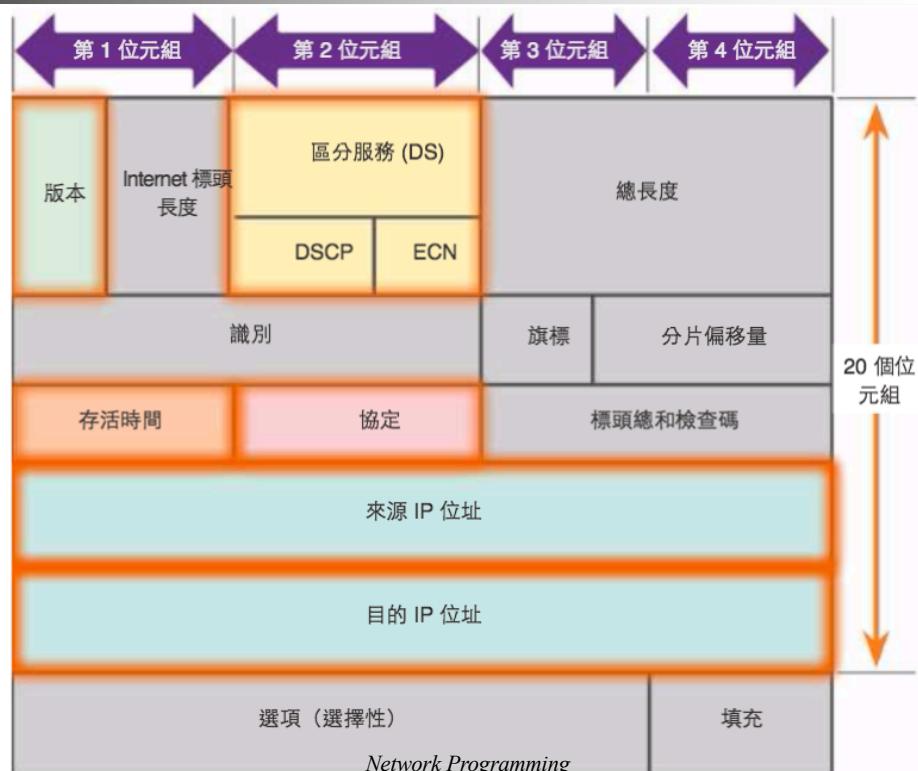
網路層協定在主機之間轉送傳輸層 PDU。

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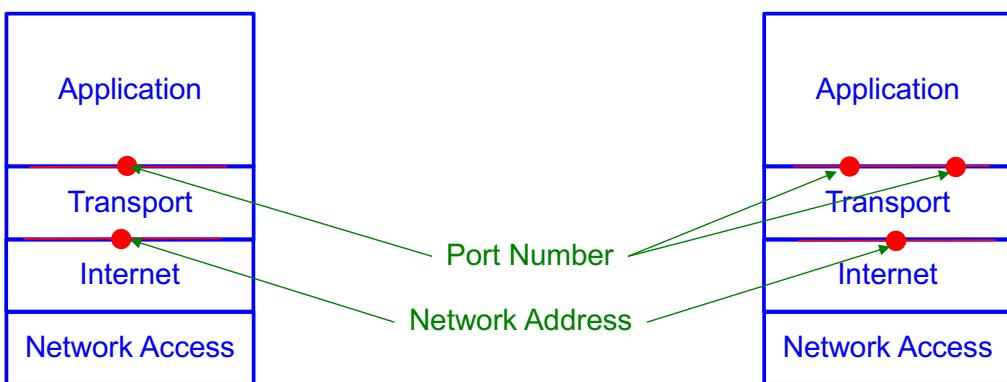
8



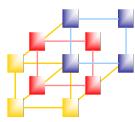
## IPv4 封包標頭



## IP 與 Port Number



服務 (Service) 是在主機背景執行的一支程式，通常系統服務都會占用一個埠號 (Port)，等待外部連線的要求



## 常用連接埠

連接埠號範圍	連接埠組
0 到 1023	公認連接埠
1024 到 49151	註冊連接埠
49152 到 65535	私有和/或動態連接埠

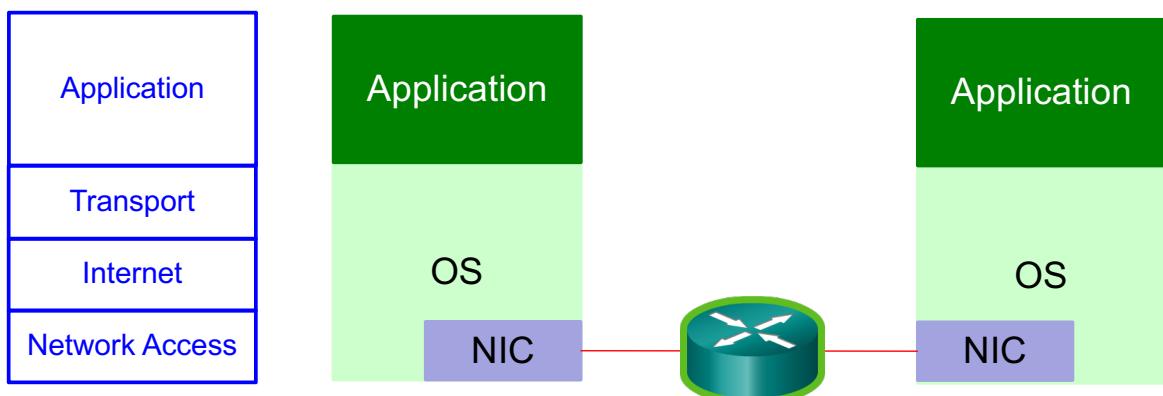
已註冊的 TCP 連接埠： 1863 MSN Messenger 2000 Cisco SCCP (VoIP) 8008 備用 HTTP 8080 備用 HTTP	公認的 TCP 連接埠： 21 FTP 23 Telnet 25 SMTP 80 HTTP 143 IMAP 194 Internet 中繼聊天 (IRC) 443 安全 HTTP (HTTPS)
已註冊的 UDP 連接埠： 1812 RADIUS 驗證協定 5004 RTP (語言和視訊傳輸協定) 5060 SIP (VoIP)	公認的 UDP 連接埠： 69 TFTP 520 RIP
已註冊的 TCP/UDP 通用連接埠： 1433 MS SQL 2948 WAP (MMS)	公認的 TCP/UDP 通用連接埠： 53 DNS 161 SNMP 531 AOL Instant Messenger , IRC

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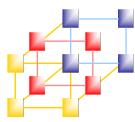


## 基本觀念(1/2)



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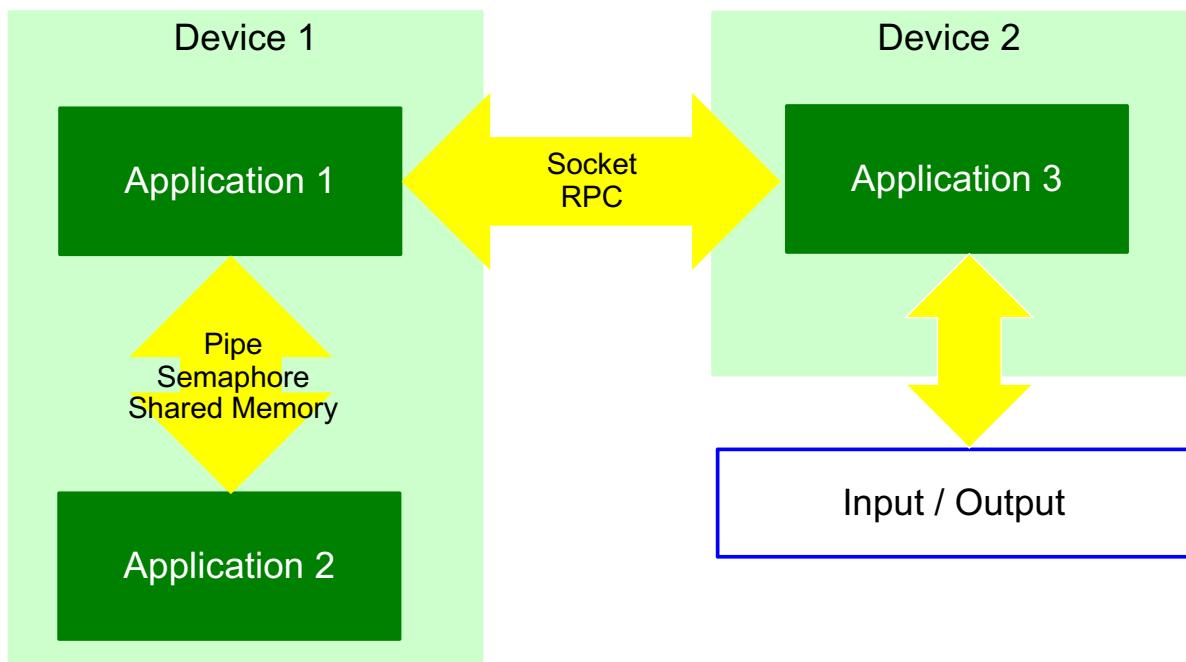


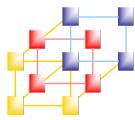
## 基本觀念(2/2)

- 應用程式的網路通訊主要透過系統呼叫 (System Call) 或函式庫 (Library) 來進行
  - 以Java來說，主要使用 java.net package
  - 函式庫也是透過呼叫作業系統的服務來啟動網路通訊的指令
  - 通訊的方式主要依照 TCP/IP 網路協定的標準
- 常用的網路通訊函式庫有兩種
  - 通訊槽介面 (Socket interface)
  - 遠端程序呼叫 (RPC, Remote procedure call)



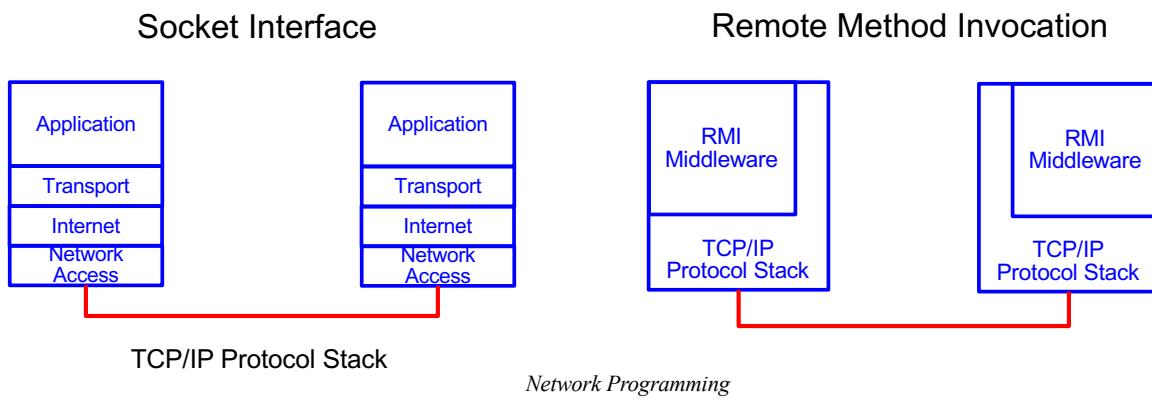
## 程式間訊息溝通的方法





# Java 網路通訊函式庫的種類

- Socket interface
  - 須考慮各種通訊的細節（例如資料型式與結構的轉換、連線的管理等）
- RMI (Remote Method Invocation)
  - 將網路通訊看成是程式中的程序
  - 對應於 RPC 或 Windows 的 Winsock

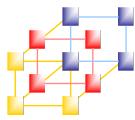


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## 通訊槽 (Socket) 介面

- TCP 與 UDP 都支援 Socket interface
  - 目前除了 UNIX 作業系統之外，其他的各種硬體平台及作業系統，也都支援 TCP/IP 與 Socket
- Socket 介面的主要內涵是提供通訊的功能，並且藉由程序中參數的設定使呼叫程式有各種調整的彈性
- 軟體層面通訊管道
  - 連線導向 (Connection-oriented) 的軟體通訊管道
  - 非連線導向的 (Connectionless) 軟體通訊管道

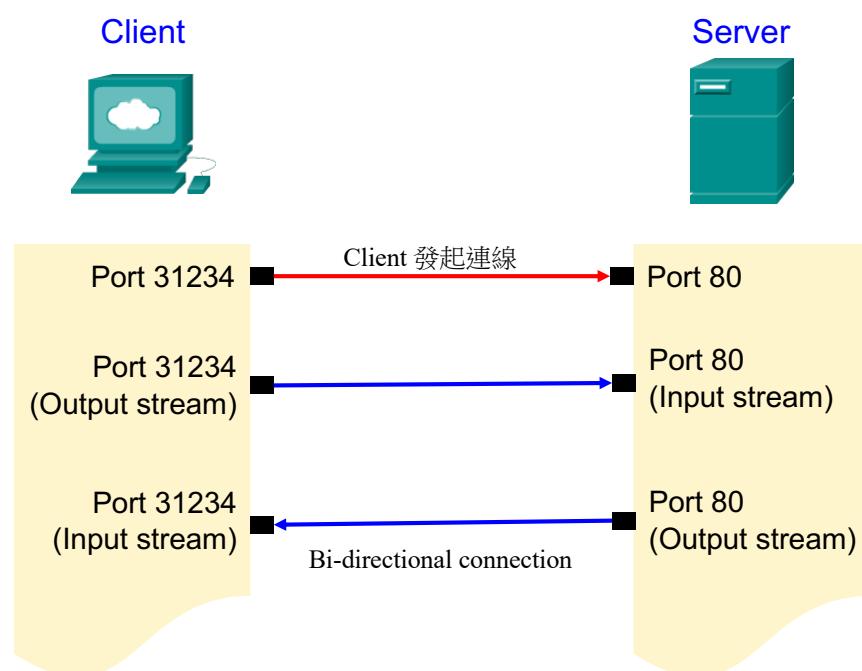


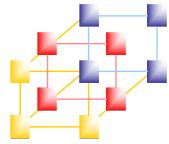
# 傳輸層 (Transport Layer)

- 傳輸層主要的功能是提供通訊的兩個節點之間一種穩定又節省成本的資料傳輸服務
  - 不管底下的實體網路是那一種，都能維持一樣的服務品質
  - 傳輸層中負責主要工作的軟硬體也稱為傳輸主體(Transport entity)
- 傳輸層的服務
  - Connection-oriented connection – TCP
    - Stream Socket
  - Connectionless connection – UDP
    - Datagram socket



# 主從式架構





## 解析網路封包



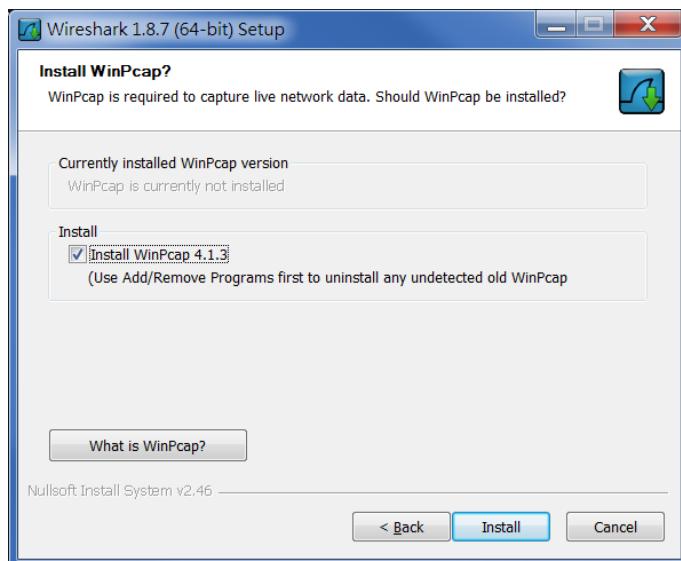
## 下載 Wireshark

- <http://www.wireshark.org/download.html>

The screenshot shows a web browser window displaying the official Wireshark download page at [www.wireshark.org/download.html](http://www.wireshark.org/download.html). The page features the Wireshark logo and navigation links for 'Get Acquainted', 'Get Help', and 'Develop'. A prominent blue header bar says 'Download Wireshark'. Below it, a message states: 'The current stable release of Wireshark is 1.10.5. It supersedes all previous releases. You can also download the latest development release (1.11.2) and documentation.' A green sidebar on the left lists 'Stable Release (1.10.5)' options: Windows Installer (64-bit), Windows Installer (32-bit), Windows U3 (32-bit), Windows PortableApps (32-bit), OS X 10.6 and later Intel 64-bit .dmg, OS X 10.5 and later Intel 32-bit.dmg, and Source Code. Other sections include 'Old Stable Release (1.8.12)', 'Development Release (1.11.2)', 'Documentation', 'Having Problems?', and 'Installation Notes'. On the right, there's a 'Our Sponsor' section for Riverbed, an 'Enhance Wireshark' button, a 'Troubleshoot your Network' sidebar with a 'Free 30 day trial' offer, a '802.11 Packet Capture' sidebar with a 'Learn More' and 'Buy Now' button, and a 'Packet Analysis Made Easy' sidebar.



- WinPcap 是 Windows 版本的 lippcap 函式庫
  - Wireshark 使用 WinPcap 函式庫抓取網路上的封包



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## Wireshark 起始畫面



### Welcome to Wireshark

#### Capture

...using this filter:

Wi-Fi: en0  
awdl0  
Thunderbolt Bridge: bridge0  
Thunderbolt 1: en1  
Thunderbolt 2: en2  
p2p0  
Thunderbolt Ethernet: en4  
Loopback: lo0

#### Learn

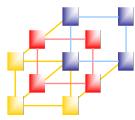
[User's Guide](#) · [Wiki](#) · [Questions and Answers](#) · [Mailing Lists](#)

You are running Wireshark 2.0.1 (v2.0.1-0-g59ea380 from master-2.0).



Network Programming

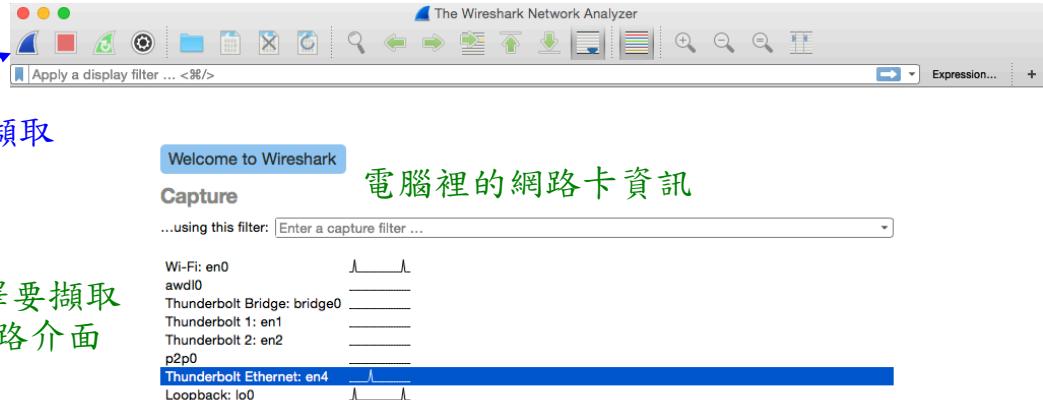
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## 封包截取 (1/2)

### 2. 開始擷取

#### 1. 選擇要擷取的網路介面



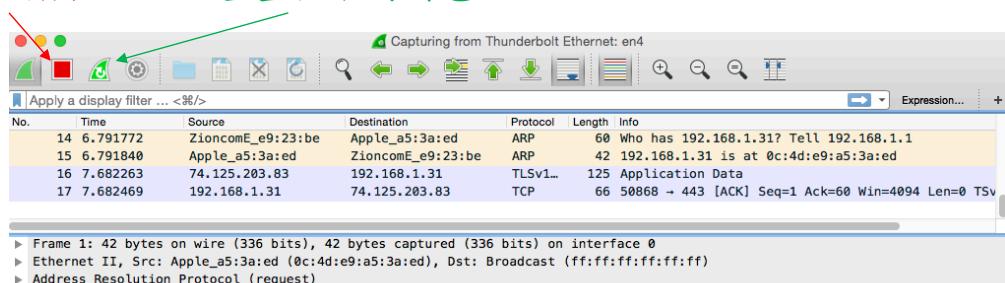
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## 封包截取 (2/2)

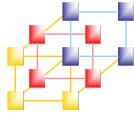
### 3. 停止擷取

### 重置抓取的封包



```
0000 ff ff ff ff ff 0c 4d e9 a5 3a ed 08 06 00 01 .....M ..:.....
0010 08 00 06 04 00 01 0c 4d e9 a5 3a ed c0 a8 01 1f .....M ..:.....
0020 00 00 00 00 00 00 c0 a8 01 c8 ..... .
```

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## 過濾器

- 從擷取的封包中過濾出我們要的封包
  - 語法：[通訊協定][運算元][數值]
- 通訊協定
  - tcp、udp、dns、  
ftp、ip、ssh、...
- 運算元
  - ==、!=、>、<、  
>=、<=
- Example
  - dns
  - ip.addr == 192.168.1.22
  - tcp.port >= 80

Thunderbolt Ethernet: en0

tcp

No.	Time	Source	Destination	Protocol	Length	Info
1124	8_-	74.125.203.83	192.168.1.31	TCP	66	443 → 50868 [ACK] Seq=1422 Ack=1005 Win=0 TSval=...
1125	8_-	64.233.189.125	192.168.1.31	XMPPL_	183	UNKNOWN PACKET
1126	8_-	192.168.1.31	64.233.189.125	TCP	66	49389 → 5222 [ACK] Seq=223 Ack=38 Win=4094 Len=0 TSval=2...
1151	9_-	74.125.203.83	192.168.1.31	TLSV1_	125	Application Data
1152	9_-	192.168.1.31	74.125.203.83	TCP	66	50868 → 443 [ACK] Seq=1005 Ack=1481 Win=0 TSval=...

Frame 11: 82 bytes on wire (656 bits), 82 bytes captured (656 bits) on interface 0  
 ▶ Ethernet II, Src: Apple\_16:e0:f7 (20:c9:d0:16:e0:f7), Dst: Apple\_a5:3a:ed (0c:4d:e9:a5:3a:ed)  
 ▶ Internet Protocol Version 4, Src: 192.168.1.200, Dst: 192.168.1.31  
 ▶ Transmission Control Protocol, Src Port: 548 (548), Dst Port: 50152 (50152), Seq: 1, Ack: 1, Len: 16  
 ▶ Data Stream Interface

0000 0c 4d e9 a5 3a d0 c9 d0 16 e0 f7 08 00 45 20 .M...:.. . ....E  
 0010 09 44 63 40 00 00 00 06 53 12 e0 a8 01 c8 e0 a8 ..D...@. S.....  
 0020 01 1f 02 24 c3 e8 05 37 a9 3d 6d 63 ba d7 08 08 ..S...7 ...mc...  
 0030 c0 00 5a aa 00 00 01 01 08 0a 00 00 17 4d 0e e5 ..Z.... ....M.  
 0040 6d ce 00 05 27 00 00 00 00 00 00 00 00 00 00 00 m...!.... ....  
 0050 00 00 ..

Packets: 1180 - Displayed: 1098 (94.7%) Profile: Default



## 多條件過濾

- 語法：[表達式] [邏輯運算符] [其他表達式]
  - 邏輯運算符
    - &&、||、^^、!

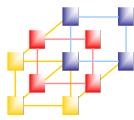
Thunderbolt Ethernet: en0

tcp.port == 443 || udp.port == 443

No.	Time	Source	Destination	Protocol	Length	Info
2491	2_-	192.168.1.31	111.221.76.162	TCP	66	49324 → 443 [ACK] Seq=2760 Ack=10917 Win=3999 Len=0 TSval=...
2492	2_-	192.168.1.31	111.221.76.162	TCP	66	[TCP Window Update] 49324 → 443 [ACK] Seq=2760 Ack=10917...
2493	2_-	192.168.1.31	111.221.76.162	TLSV1	911	Application Data
2494	2_-	111.221.76.162	192.168.1.31	TCP	66	443 → 49324 [ACK] Seq=18917 Ack=3605 Win=65535 Len=0 TSval=...
2505	2_-	13.75.42.223	192.168.1.31	TCP	60	443 → 51036 [RST, ACK] Seq=3726 Ack=441 Win=0 Len=0

Frame 5: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0  
 ▶ Ethernet II, Src: Apple\_a5:3a:ed (0c:4d:e9:a5:3a:ed), Dst: ZioncomE\_e9:23:be (08:55:10:e9:23:be)  
 ▶ Internet Protocol Version 4, Src: 192.168.1.31, Dst: 74.125.203.138  
 ▶ Transmission Control Protocol, Src Port: 50987 (50987), Dst Port: 443 (443), Seq: 1, Ack: 1, Len: 0

0000 b8 55 10 e9 23 be 0c 4d e9 a5 3a ed 08 00 45 00 .U...#..M .....E.  
 0010 00 28 4b be 00 00 40 06 00 00 c0 a8 01 1f 4a 7d .(K...@ .....J)  
 0020 cb 8a c7 2b 01 bb 23 f9 e0 a1 68 c5 81 7c 50 10 ...+..#..h..|P..  
 0030 10 00 d7 e9 00 00 .....



## 封包追蹤

封包編號 時間 來源 目的地 協定 封包位元數 其他訊息

No.	Time	Source	Destination	Protocol	Length	Info
2491	2...	192.168.1.31	111.221.76.162	TCP	66	49324 → 443 [ACK] Seq=2760 Ack=10917 Win=3999 Len=0 TSva...
2492	2...	192.168.1.31	111.221.76.162	TCP	66	[TCP Window Update] 49324 → 443 [ACK] Seq=2760 Ack=10917...
2493	2...	192.168.1.31	111.221.76.162	TLSv1	911	Application Data
2494	2...	111.221.76.162	192.168.1.31	TCP	66	443 → 49324 [ACK] Seq=10917 Ack=3605 Win=65535 Len=0 TSv...
2505	2...	13.75.42.223	192.168.1.31	TCP	66	443 → 51036 [RST, ACK] Seq=3726 Ack=441 Win=0 Len=0

```

▶ Frame 5: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0
▶ Ethernet II, Src: Apple_a5:3a:ed (0c:4d:e9:a5:3a:ed), Dst: Zioncome_e9:23:be (b8:55:10:e9:23:be)
▶ Internet Protocol Version 4, Src: 192.168.1.31, Dst: 74.125.203.138
▶ Transmission Control Protocol, Src Port: 50987 (50987), Dst Port: 443 (443), Seq: 1, Ack: 1, Len: 0

```

Frame 5: 54 bytes on wire (432 bits), 54 bytes captured (432 bits) on interface 0  
Ethernet II, Src: Apple\_a5:3a:ed (0c:4d:e9:a5:3a:ed), Dst: Zioncome\_e9:23:be (b8:55:10:e9:23:be)  
Internet Protocol Version 4, Src: 192.168.1.31, Dst: 74.125.203.138  
Transmission Control Protocol, Src Port: 50987 (50987), Dst Port: 443 (443), Seq: 1, Ack: 1, Len: 0

0000 b8 55 10 e9 23 be 0c 4d e9 a5 3a ed 08 00 45 00 .U..#.M .....E.  
0010 00 28 4b be 00 00 48 06 00 00 c8 a1 01 1f 4a 7d .(K...@. ....J}  
0020 cb 8a c7 2b 01 bb 23 f9 e0 a1 68 c5 81 7c 50 10 ...+.#. ..h..|P.  
0030 10 00 d7 e9 00 00 .....

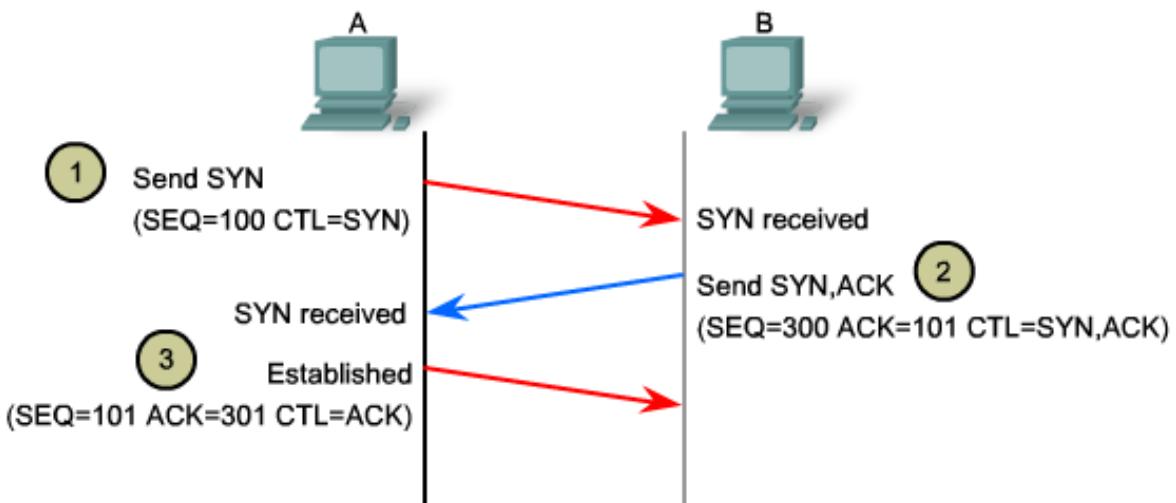
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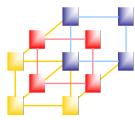
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## Steps in the TCP Handshake (1/5)

- TCP Connection Establishment





## Steps in the TCP Handshake (2/5)

TCP 三向交握 (SYN)

13	6.201109	192.168.254.254	10.1.1.1	DNS	Standard query r
14	6.202100	10.1.1.1	192.168.254.254	TCP	1069 > http [SYN]
15	6.202513	192.168.254.254	10.1.1.1	TCP	http > 1069 [SYN]
16	6.202543	10.1.1.1	192.168.254.254	TCP	1069 > http [ACK]
17	6.202651	10.1.1.1	192.168.254.254	HTTP	GET / HTTP/1.1

Frame 14 (62 bytes on wire, 62 bytes captured)  
Ethernet II, Src: QuantaCo\_bd:0c:7c (00:c0:9f:bd:0c:7c), Dst: Cisco\_cf:66:40 (00:0c:85:cf:66:40)  
Internet Protocol, Src: 10.1.1.1 (10.1.1.1), Dst: 192.168.254.254 (192.168.254.254)  
Transmission Control Protocol, src Port: 1069 (1069), Dst Port: http (80), Seq: 0, Ack: 1, Len: 62  
Source port: 1069 (1069)  
Destination port: http (80)  
Sequence number: 0 (relative sequence number)  
Header length: 28 bytes  
Flags: 0x02 (SYN)  
    0... .... = Congestion window Reduced (CWR): Not set  
    .0... .... = ECN-Echo: Not set

通訊協定分析器顯示了訊框 14 中的用戶端初始會談請求。

此訊框中的 TCP 資料段顯示：

- SYN 旗標設置以使初始序號生效
- 採用隨機序號有效（相對值為 0）
- 隨機來源連接埠 1069
- 公認目的連接埠 80 (HTTP 連接埠) 表示 Web 同伺服器 (http)

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## Steps in the TCP Handshake (3/5)

TCP 三向交握 (SYN, ACK)

13	6.201109	192.168.254.254	10.1.1.1	DNS	Standard query r
14	6.202100	10.1.1.1	192.168.254.254	TCP	1069 > http [SYN]
15	6.202513	192.168.254.254	10.1.1.1	TCP	http > 1069 [SYN]
16	6.202543	10.1.1.1	192.168.254.254	TCP	1069 > http [ACK]
17	6.202651	10.1.1.1	192.168.254.254	HTTP	GET / HTTP/1.1

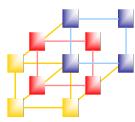
Frame 15 (62 bytes on wire, 62 bytes captured)  
Ethernet II, Src: Cisco\_cf:66:40 (00:0c:85:cf:66:40), Dst: Quantaco\_bd:0c:7c (00:c0:9f:bd:0c:7c)  
Internet Protocol, Src: 192.168.254.254 (192.168.254.254), Dst: 10.1.1.1 (10.1.1.1)  
Transmission Control Protocol, src Port: http (80), Dst Port: 1069 (1069), Seq: 1, Ack: 0, Len: 62  
Source port: http (80)  
Destination port: 1069 (1069)  
Sequence number: 0 (relative sequence number)  
Acknowledgement number: 1 (relative ack number)  
Header length: 28 bytes  
Flags: 0x12 (SYN, ACK)

通訊協定分析器顯示了訊框 15 中的伺服器回應

- ACK 標誌設置以表示有效的確認號
- 確認號以相對值 1 來回應初始序號
- SYN 標誌設置以表示從伺服器到用戶端會談的初始序號
- 目的連接埠號 1069 與用戶端來源連接埠對應
- 來源連接埠號 80 (HTTP) 表示 Web 伺服器服務 (http)

Network Programming

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## Steps in the TCP Handshake (4/5)

TCP 三向交握 (ACK)

13	6.201109	192.168.254.254	10.1.1.1	DNS	Standard query re
14	6.202100	10.1.1.1	192.168.254.254	TCP	1069 > http [SYN]
15	6.202513	192.168.254.254	10.1.1.1	TCP	http > 1069 [SYN,
16	6.202543	10.1.1.1	192.168.254.254	TCP	1069 > http [ACK]
17	6.202651	10.1.1.1	192.168.254.254	HTTP	GET / HTTP/1.1

Frame 16 (54 bytes on wire, 54 bytes captured)  
Ethernet II, Src: QuantaCo\_bd:0c:7c (00:c0:9f:bd:0c:7c), Dst: Cisco\_cf:66:40  
Internet Protocol, Src: 10.1.1.1 (10.1.1.1), Dst: 192.168.254.254 (192.168.254.254)  
Transmission Control Protocol, Src Port: 1069 (1069), Dst Port: http (80), Seq: 1, Ack: 1, Len: 54  
Source port: 1069 (1069)  
Destination port: http (80)  
Sequence number: 1 (relative sequence number)  
Acknowledgement number: 1 (relative ack number)  
Header length: 20 bytes  
Flags: 0x10 (ACK)

通訊協定分析器顯示了訊框 16 中用戶端對會談的回應

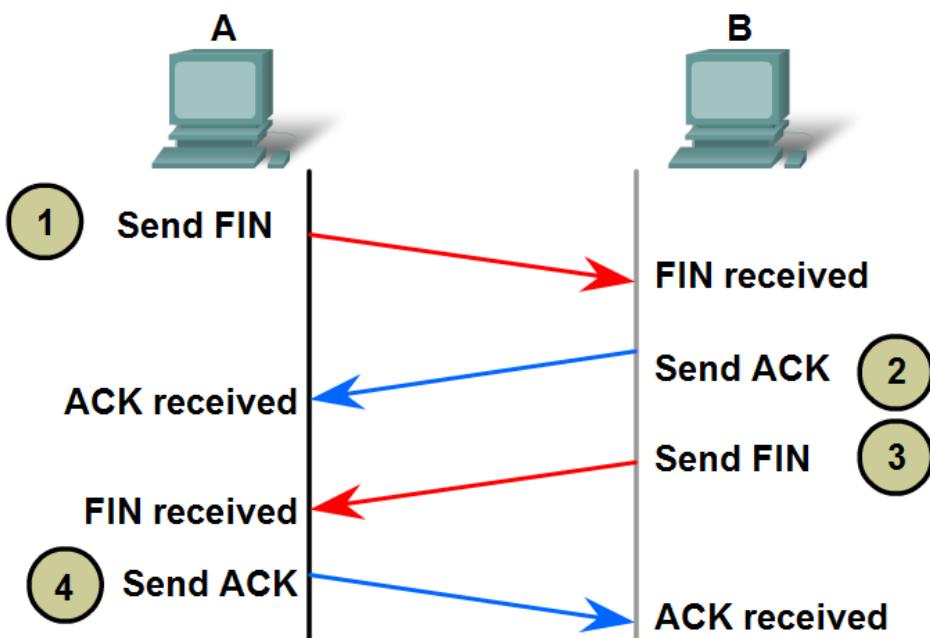
此訊框中的 TCP 資料段顯示：

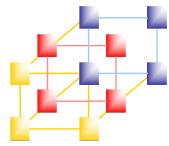
- ACK 標誌設置以表示有效的確認號
- 確認號以相對值 1 來回應初始序號
- 來源連接埠號為對應的 1069
- 目的連接埠號 80 (HTTP) 表示 Web 伺服器服務 (http)



## Steps in the TCP Handshake (5/5)

### ■ TCP Connection Termination





## Java 程式語言

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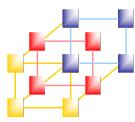


## 執行程式時可能發生的問題

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- 與系統有關的錯誤
- 和程式邏輯有關的錯誤
- Java的例外處理 (Exception handling)

```
try {      // .....try方塊  
          //程式行  
}  
catch (Exception e) {      //.....catch方塊  
          //處理例外的程式行  
}  
finally {  
          //一定會執行  
}
```



## Java 系統內定的例外

標準的執行時期例外	狀況／事件
Security Exception	執行時期違反安全性原則
Arithmetic Exception	溢位或除以 0 的狀況
Number Format Exception	String 不當轉換成數值型式
Index Out Of Bounds Exception	陣列索引值異常
Negative Array Size Exception	陣列大小為負值
Null Pointer Exception	使用不當的參變數值
系統檢查的例外	狀況／事件
java.io.IOException	和輸出與輸入有關的例外
InterruptedException	由 Thread.sleep 發出的例外
java.io.EOFException	完成輸入前遇到 End-of-file
java.io.FileNotFoundException	無法找到檔案



## 程序庫

- Class ServerSocket  
<http://docs.oracle.com/javase/7/docs/api/java/net/ServerSocket.html>
- Class Socket  
<http://docs.oracle.com/javase/7/docs/api/java/net/Socket.html>
- Class InputStream  
<http://docs.oracle.com/javase/7/docs/api/java/io/InputStream.html>
- Class OutputStream  
<http://docs.oracle.com/javase/7/docs/api/java/io/OutputStream.html>