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Network Security Architecture – Part 1

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CSC3064 Lecture 04

School of Electronics, Electrical Engineering and Computer Science

Session Overview

- Integrating security services into network architectures
  - Considerations for architectural placement
  - Considerations with respect to specific levels
  - Example network models

References:
Harris, Shon. *CISSP all-in-one exam guide*. McGraw-Hill, Inc., 2010.
Schäfer, Günter, and Michael Rossberg. *Security in Fixed and Wireless Networks*. John Wiley & Sons, 2016.

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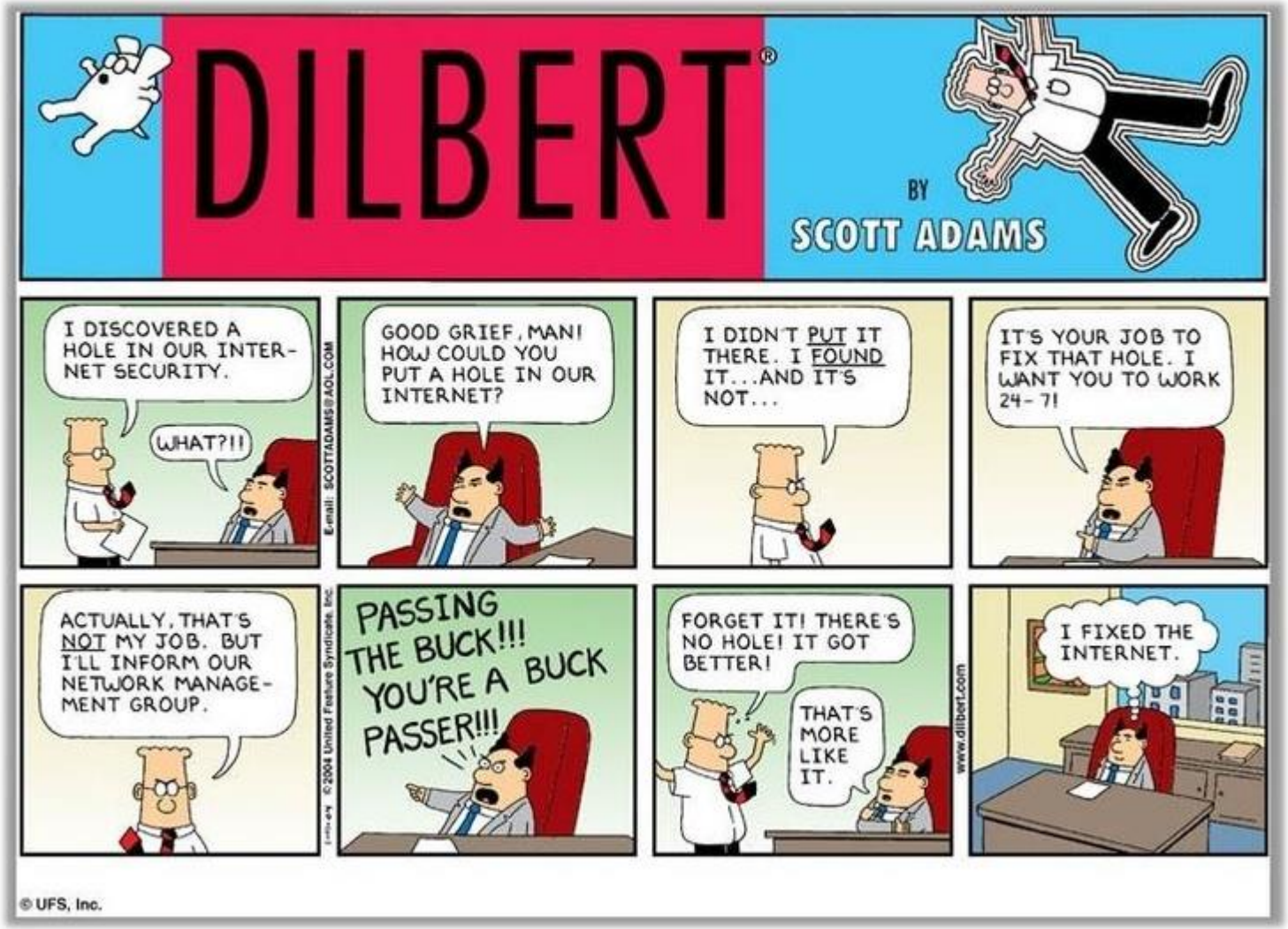
Securing the Network …



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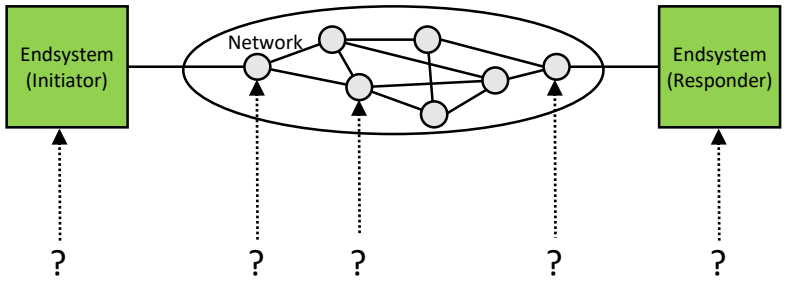
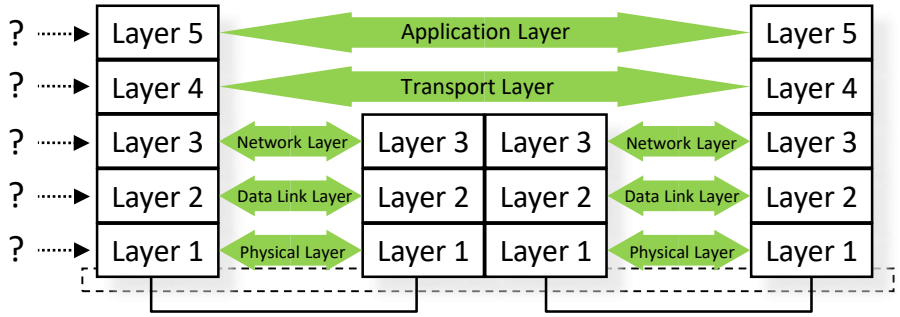
Motivation – What to do where?

Analogous to the methodology of security analysis, there are *two dimensions* guiding the integration of security services into communications architectures:





Dimension 1:

Which security service should be realized in which node?

Dimension 2:

Which security service should be realized in which layer?

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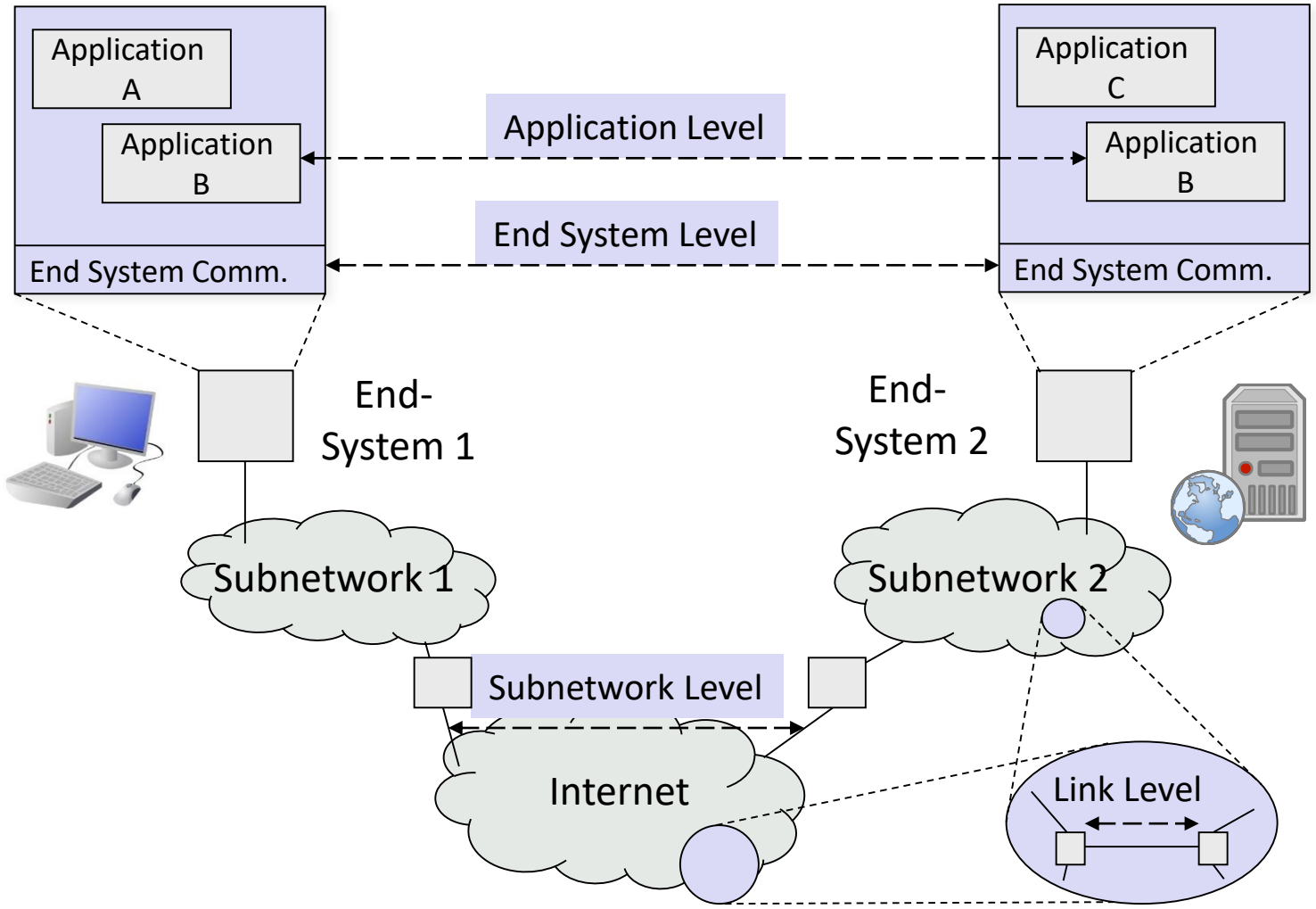
A practical model for secured & networked computing (1)



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A practical model for secured & networked computing (2)

Application:

- A piece of software that accomplishes some specific task, e.g. email, web service, file transfer, data storage, etc.

End System:

- One piece of equipment, anywhere in the range from personal computer to server to mainframe computer
- For security purposes one end system usually has one policy authority

Subnetwork:

- A collection of communication facilities under the control of one administrative organization, e.g. a LAN, campus network, WAN, etc.
- For security purposes one subnetwork usually has one policy authority

Internet:

- A collection of inter-connected subnetworks
- In general, the subnets connected in an inter-network have different policy authorities

A practical model for secured & networked computing (3)

There are four levels at which distinct requirements for security protocol elements arise:

Application level:

Security protocol elements that are application dependent

End system level:

Provision of protection on an end system to end system basis

Subnetwork level:

Provision of protection over a subnetwork or an inter-network, which is considered to be less secure than other parts of the network environment

Link level:

Provision of protection internal to a subnetwork, e.g. over a link, which is considered to be less trusted than other parts of the subnetwork environment

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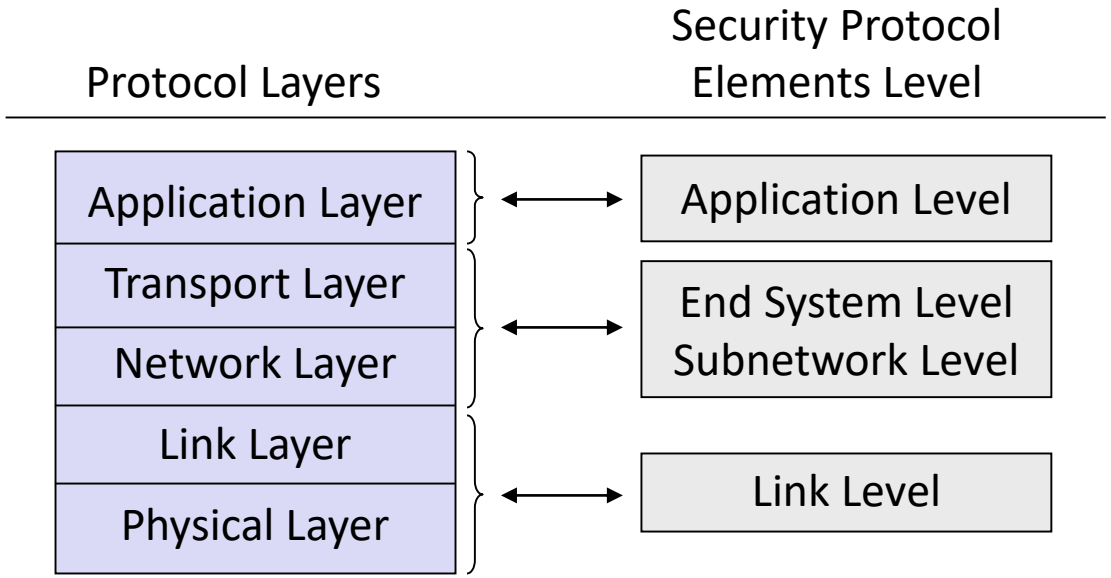
Relationships between layers and requirement levels



The relationship between protocol layers and the protocol element security requirement levels are not one-to-one:

- Security mechanisms for fulfilling both the end system and the subnetwork level requirements can either be realized in the transport and / or the network layer
- Link level requirements can be met by integrating security mechanisms or using “special functions” of either the link layer and / or the physical layer

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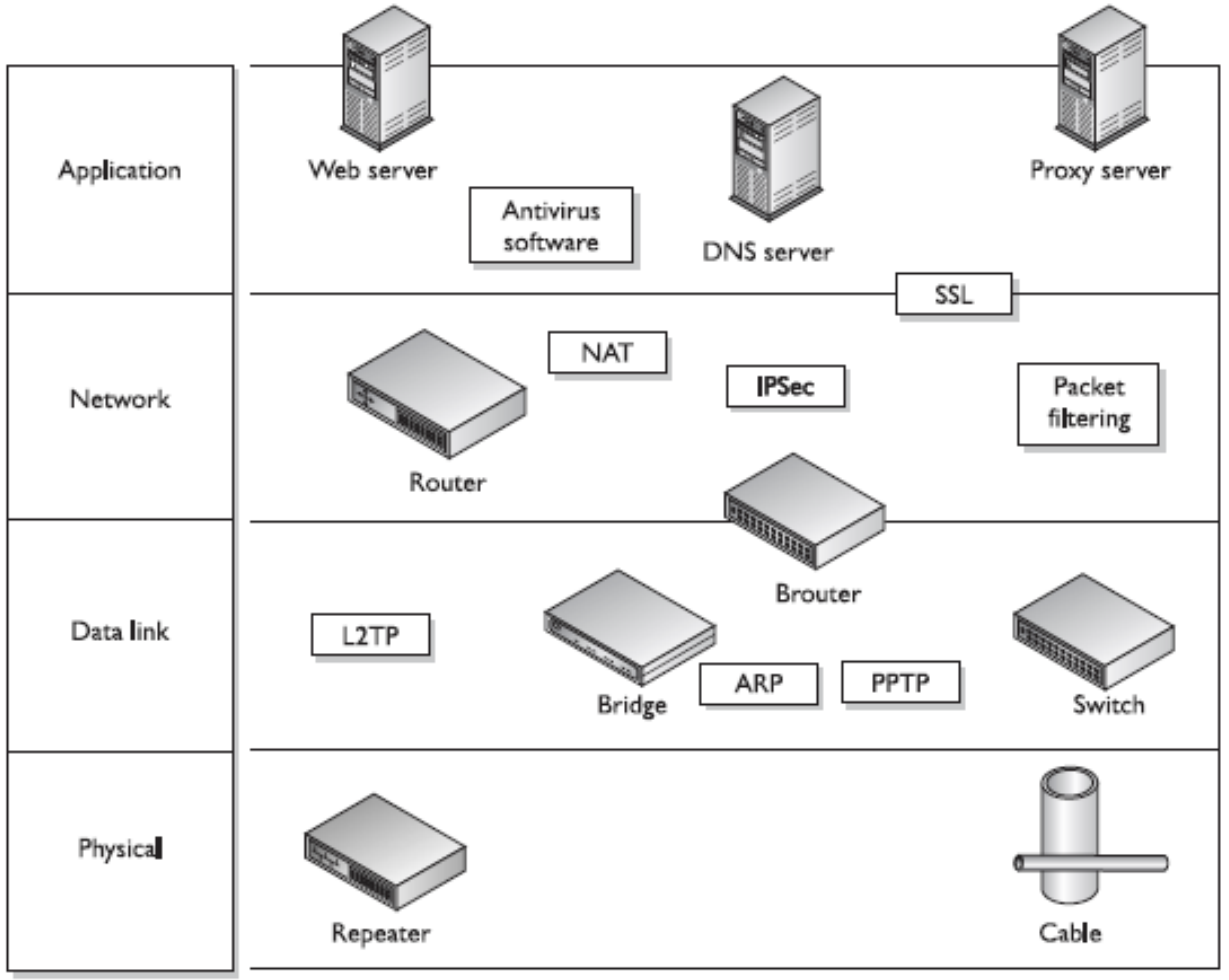
Devices and protocols and where they appear in the OSI model



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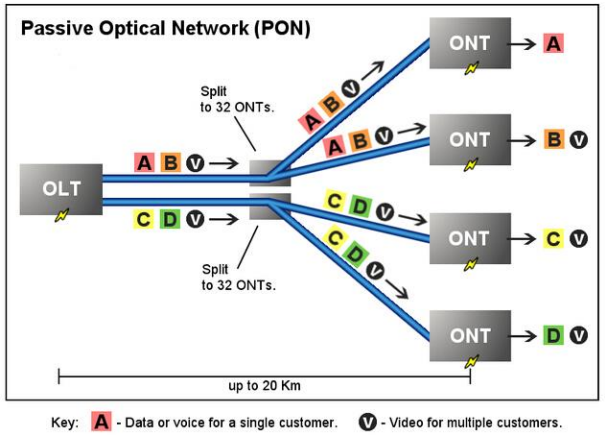
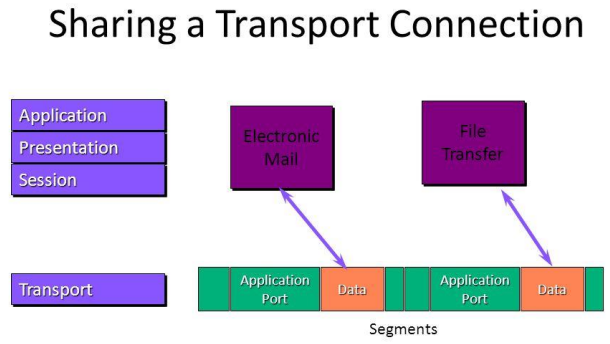
General considerations for architectural placement (1)

Traffic mixing:

- As a result of multiplexing, there is a greater tendency at lower levels to have data items from different source/destination-users and / or applications mixed in one data stream
- A security service realized at one layer / level will treat the traffic of that layer / level in an equal manner, resulting in inadequate control over security mechanisms for users and applications
- If a security policy demands a more differentiated treatment, it is better to implement it at a higher level





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General considerations for architectural placement (2)

Route knowledge:

- At lower levels, there tends to be more knowledge about the security characteristics of different routes and links
- In environments where such characteristics vary significantly, placing security at lower levels can be more effective and efficient
- Appropriate security services can be selected on a subnetwork or link basis reducing the cost for security where protection is not required

Number of protection points:

- Placing security at the application level requires security to be implemented in every sensitive application and every end system
- Placing security at the link level requires security to be implemented at the end of every network link which is considered to be less trusted
- Placing security in the middle of the architecture will tend to require security features to be installed at fewer points

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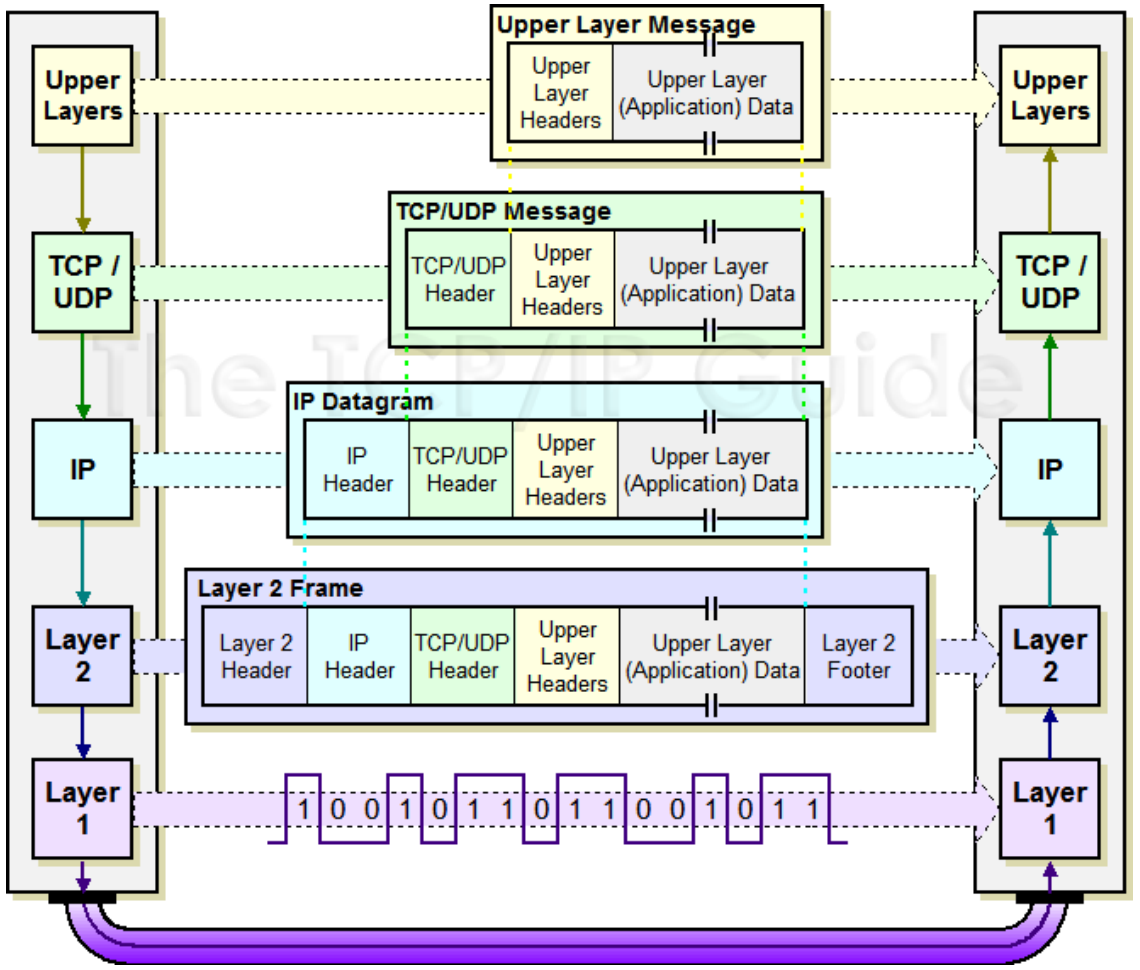
General considerations for architectural placement (3)

Protocol header protection:

- Security protection at higher levels can not protect protocol headers of lower protocol layers
- The networking infrastructure might need to be protected as well



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General considerations for architectural placement (4)

Source / sink binding:

- Security services such as data origin authentication and non-repudiation depend upon association of data with its source or sink
- This is most efficiently achieved at higher levels, in particular the application level

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Considerations with respect to specific levels (1)

Application level:

This level might be the only appropriate level, for example because:

- A security service is application specific, e.g. access control for a networked file store
- A security service needs to traverse application gateways, e.g. integrity and / or confidentiality of electronic mail
- It is outside the control of a user / application programmer to integrate security at a lower level

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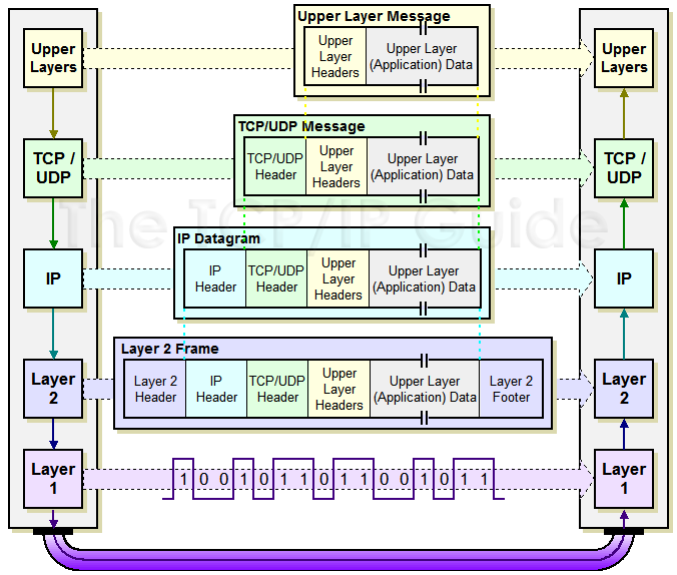
Considerations regarding specific levels (2)

End system level:

This level is appropriate when end systems are assumed to be trusted and the communication network is assumed to be untrusted

Further advantages of end system level security:

- Security services are transparent to applications
- The management of security services can be more easily handled by one system administrator



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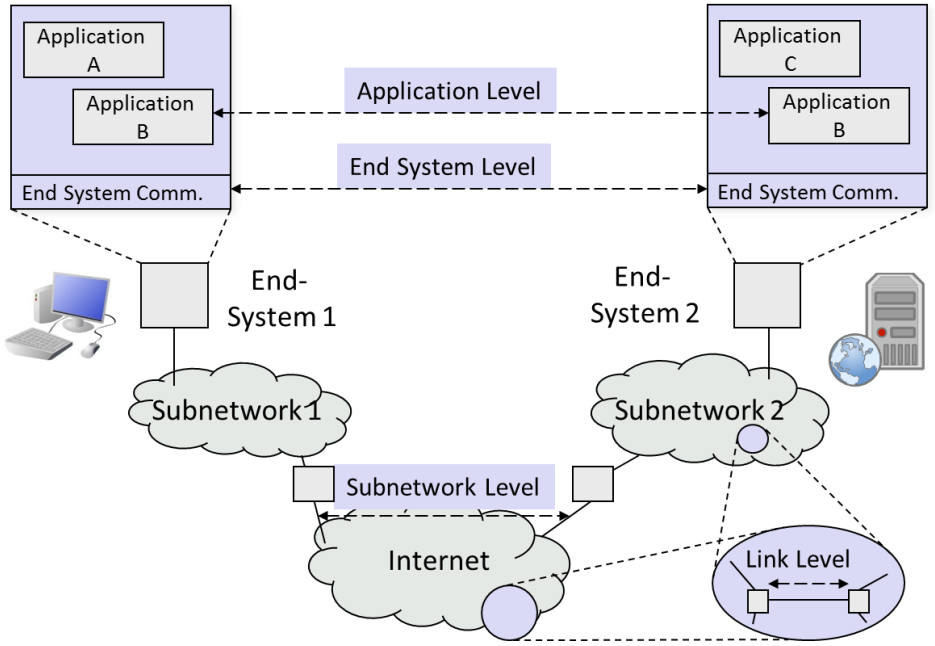
Considerations regarding specific levels (3)

Subnetwork level:

- Even if security implemented at this level might be implemented in the same protocol layer as for the end system level, these should not be mixed up:
  - With security implemented at the subnetwork level, usually the same protection is realized for all end systems of that subnetwork
- It is very common that a subnetwork close to an end system is considered equally trusted as they are on the same premises and administered by the same authorities
- In most situations, there are far fewer subnetwork gateways to be secured than there are end systems



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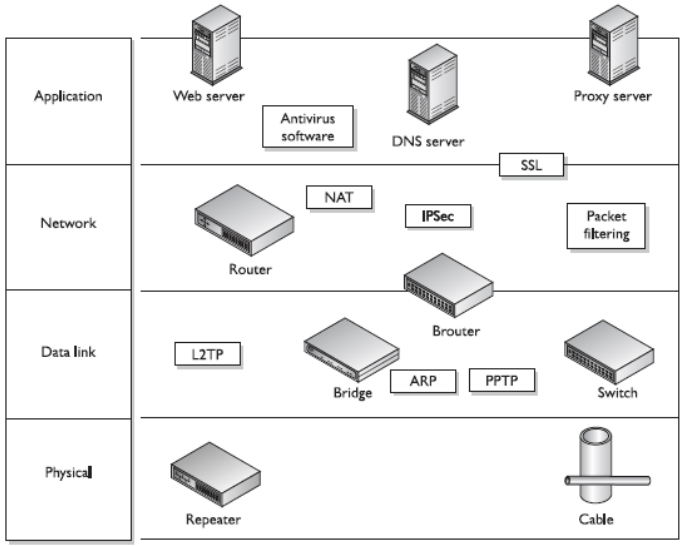
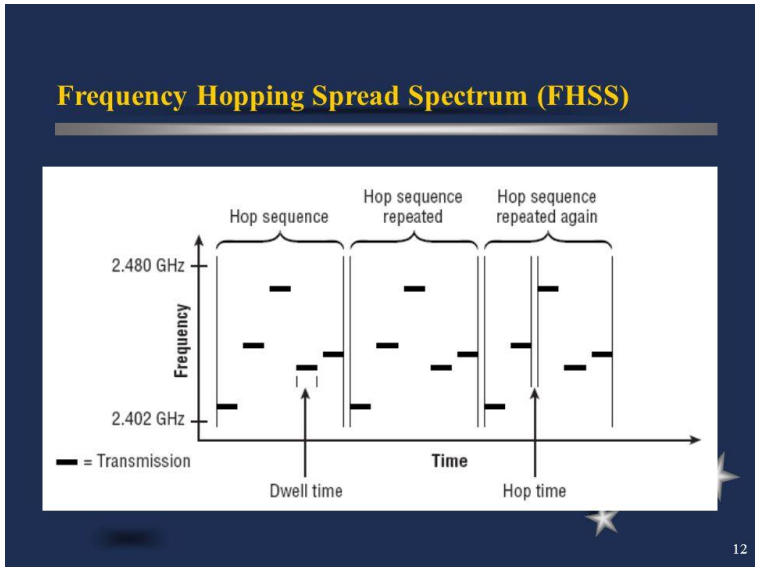
Considerations regarding specific levels (4)

Link level:

- If there are relatively few untrusted links, it might be sufficient, easier and cheaper to protect the network at the link level
- Furthermore, the link level allows to make use of specific protection techniques, such as spread spectrum or frequency hopping techniques
- Traffic flow confidentially usually demands link level protection





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Human user interactions (1)

- Some network security services involve direct interaction with a human user, the most important one being authentication
- Such interactions do not cleanly fit into any of the architectural options presented so far, as the user is external to the communication facilities

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Human user interactions (2)

- Communications supporting authentication can be realized in one of the following ways:

  Locally:

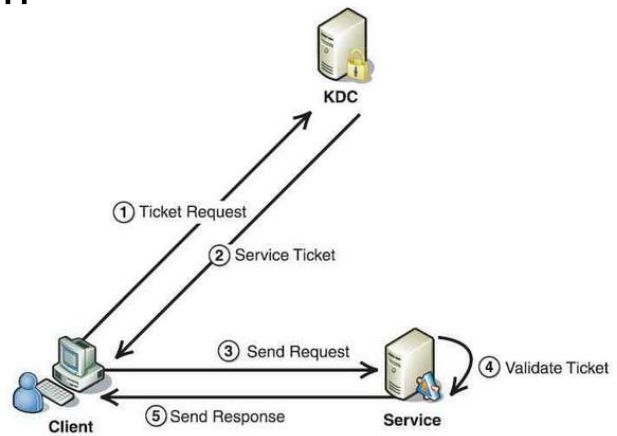
  - The human user authenticates to the local end system
  - The end system authenticates itself to the remote end system and advises the user identity
  - The remote system has to trust the local end system

  Involving protocol elements at the application layer:

  - The user passes some authentication information to the local system, which is securely relayed to the remote system

  The combination of these is, for example:

  - Kerberos



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Integration into lower protocol layers vs. applications

Benefits of integrating security services into lower network layers:

Stronger Security:

- The network itself also needs to be protected
- Security mechanisms realised in the network elements (esp. in hardware) are often harder for network users to attack

Application Independence:

- Basic network security services need not be integrated into every single application

Quality of Service (QoS):

- QoS preserving scheduling of the communication subsystem can also schedule encryption of co-existing data streams
- Example: simultaneous voice call and FTP transfer

Efficiency:

- Hardware support for computationally intensive encryption / decryption can be more easily integrated into protocol processing

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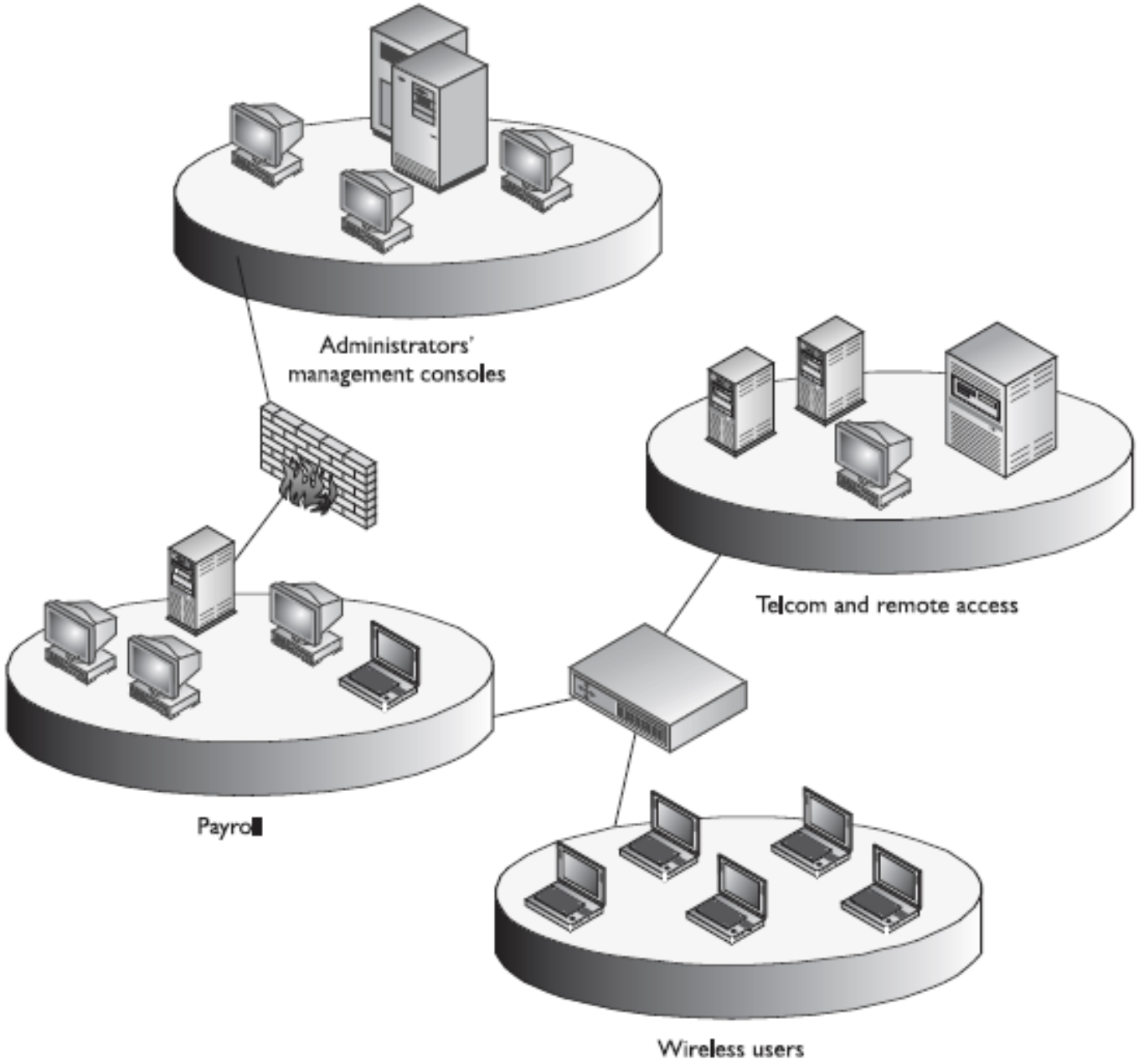
Example Network Models (1)

Illustrating separate sub-networks for different functions of an organisation requiring different security policies.



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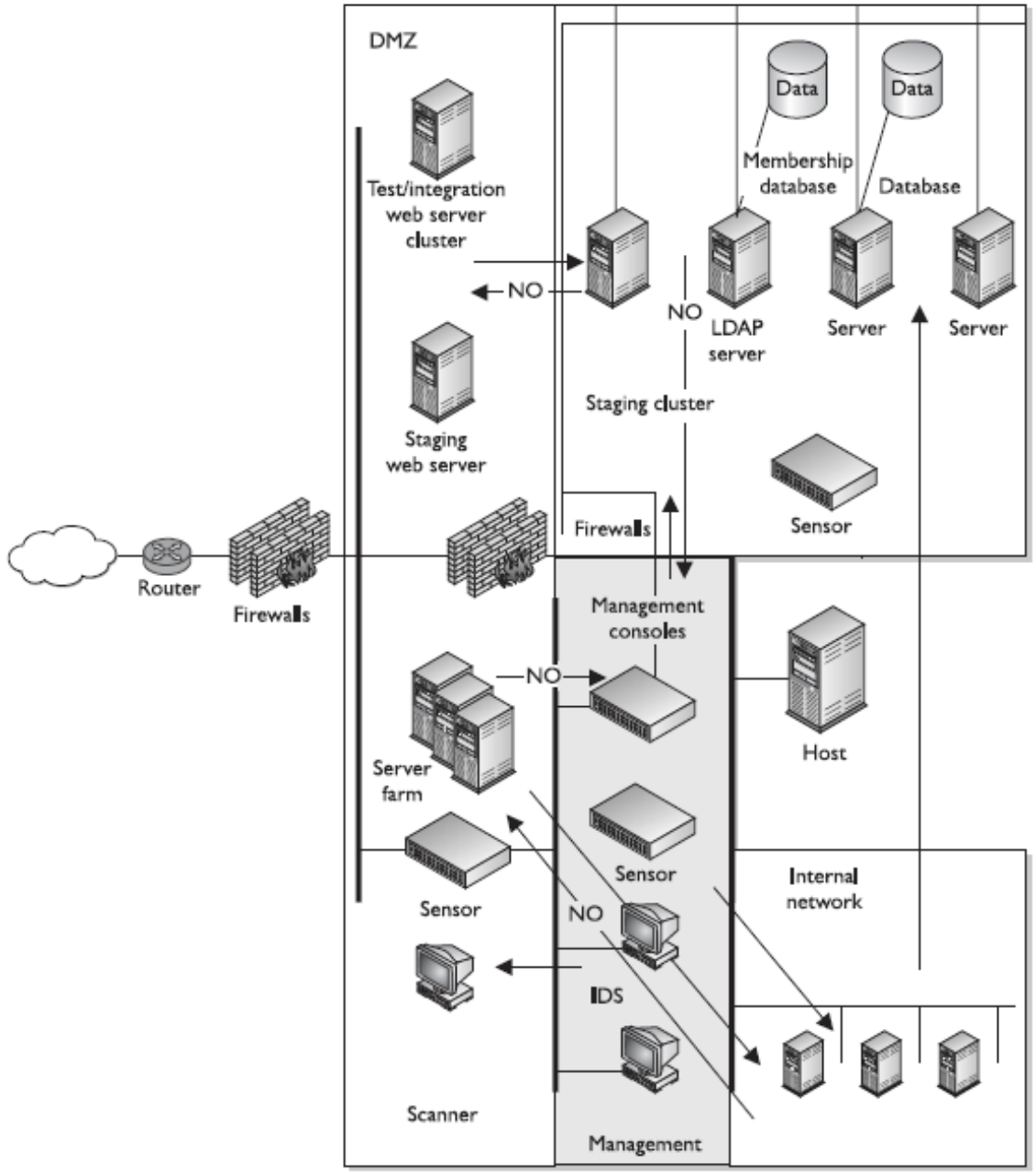
Example Network Models (2)

Another enterprise example:

Identify the different security services. We'll be looking at these individually during this course.



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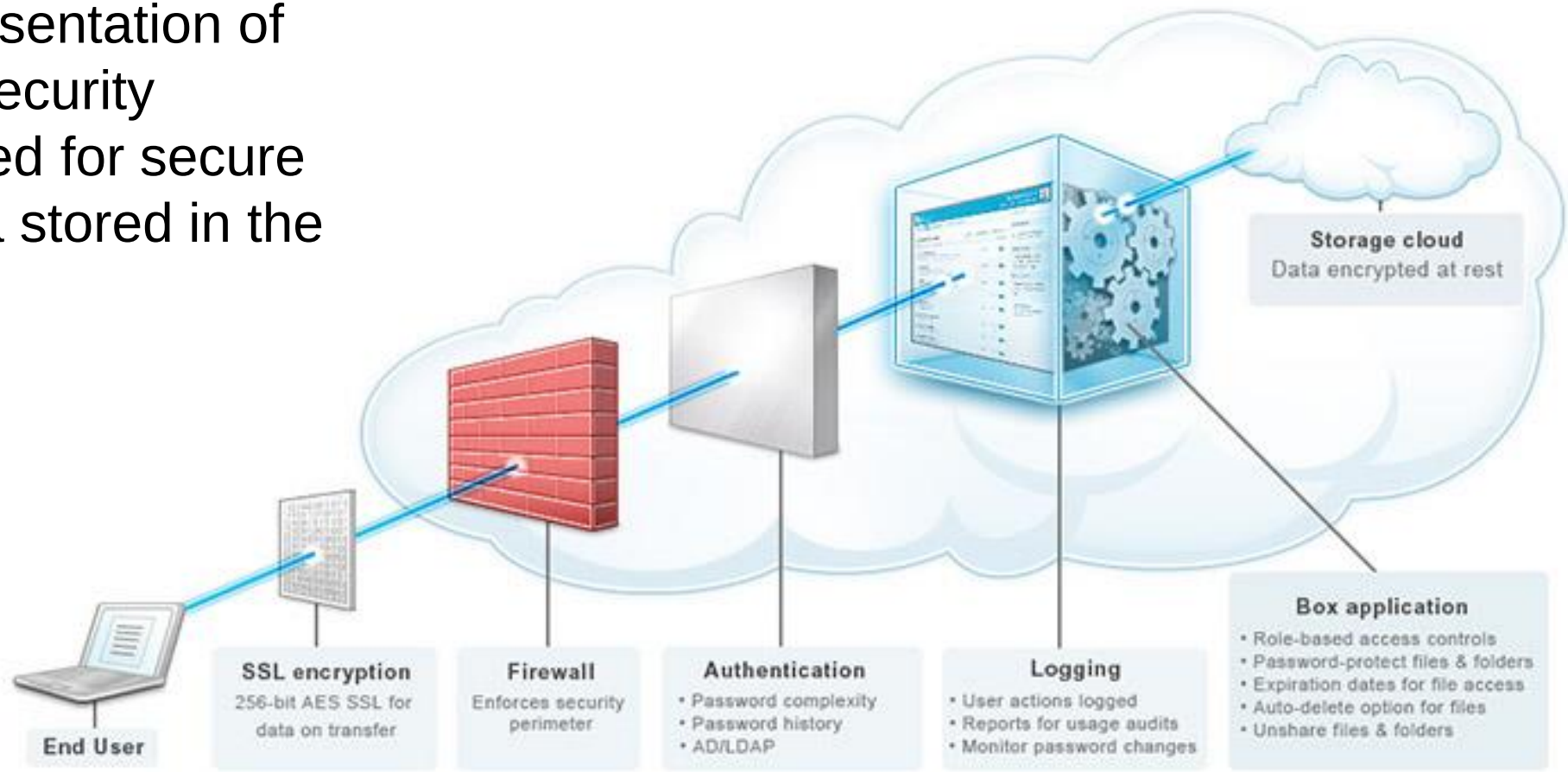
Example Network Models (3)

This is a representation of the series of security services applied for secure access to data stored in the cloud.



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Summary

- Integration of security services into communications architectures is guided by two main questions:
  - Which security service into which node?
  - Which security service into which layer?
- These design choices can also be guided by looking at a practical model of networked computing, which distinguishes four different levels at which security services may be realized:
  - Application / end system / subnetwork / link level
- As there are various reasons for and against each option, there is no single solution to this design problem
- In this course we will, therefore, study some examples of security services integration into network architectures in order to better understand the implications of the design choices made

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Questions?

Next Session: Network Security Architecture – Part 2

Thursday, 24 January 2019

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