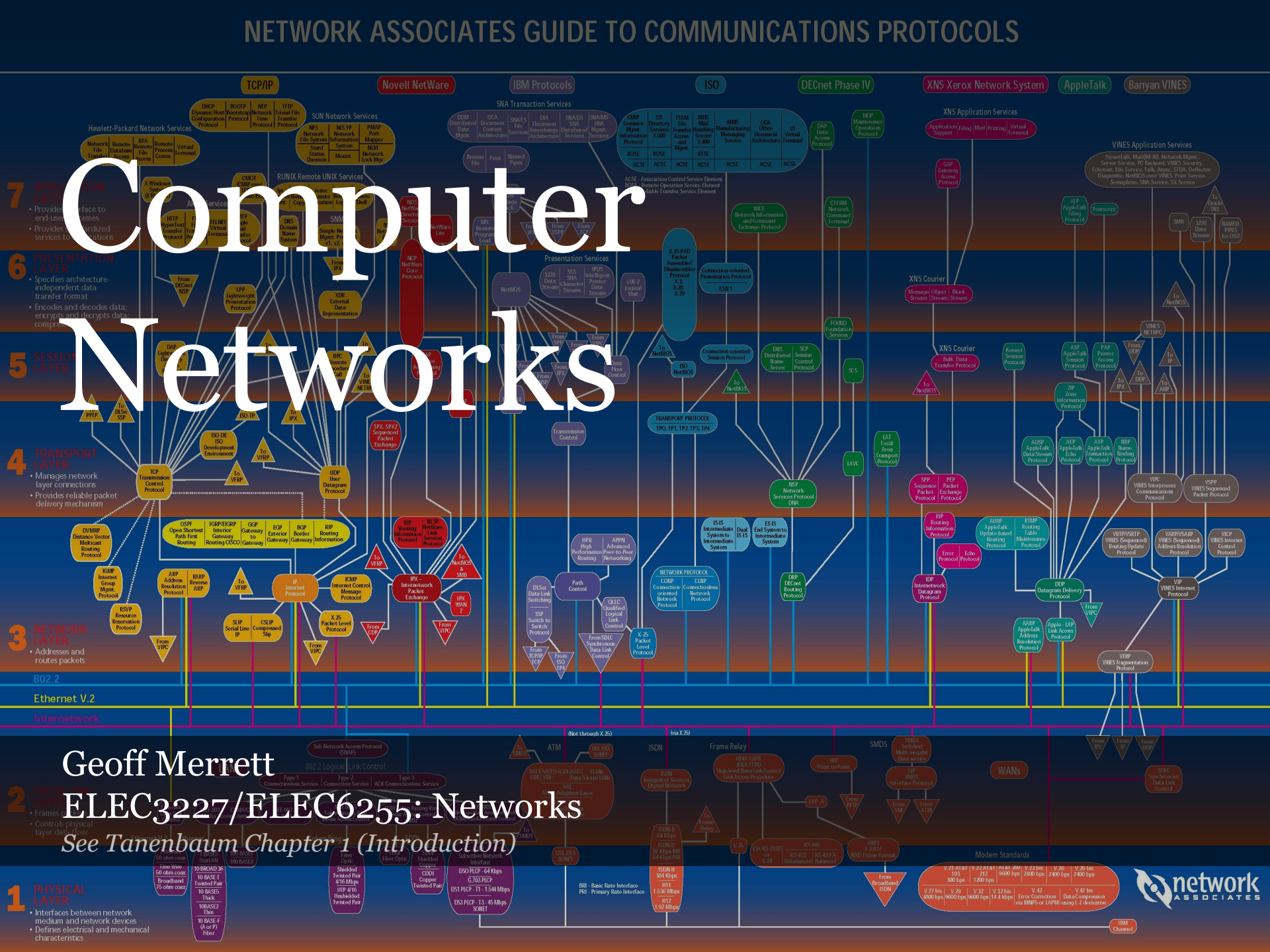
NETWORK ASSOCIATES GUIDE TO COMMUNICATIONS PROTOCOLS
TCP/IP
Novell NetWare
IBM Protocols
ISO
DECnet Phase IV
XNS Xerox Network System
AppleTalk
Banyan VINES
7 APPLICATION LAYER
• Provides interface to end-user processes
• Provides standardized services to applications
6 PRESENTATION LAYER
• Specifies architecture-independent data transfer format
• Encodes and decodes data; encrypts and decrypts data; compresses
5 SESSION LAYER
4 TRANSPORT LAYER
• Manages network layer connections
• Provides reliable packet delivery mechanism
3 NETWORK LAYER
• Addresses and routes packets
802.2
Ethernet V.2
Internetwork
2 DATA LINK LAYER
• Frames packets
• Controls physical layer data flow
1 PHYSICAL LAYER
• Interfaces between network medium and network devices
• Defines electrical and mechanical characteristics
Computer Networks
Geoff Merrett
ELEC3227/ELEC6255: Networks
See Tanenbaum Chapter 1 (Introduction)

Outline

- Why (or what) networks?
- Layered protocols
- Reference models
- The Physical Layer (very briefly!)
- Some basic definitions
- The schedule for this module (*revisited*…)

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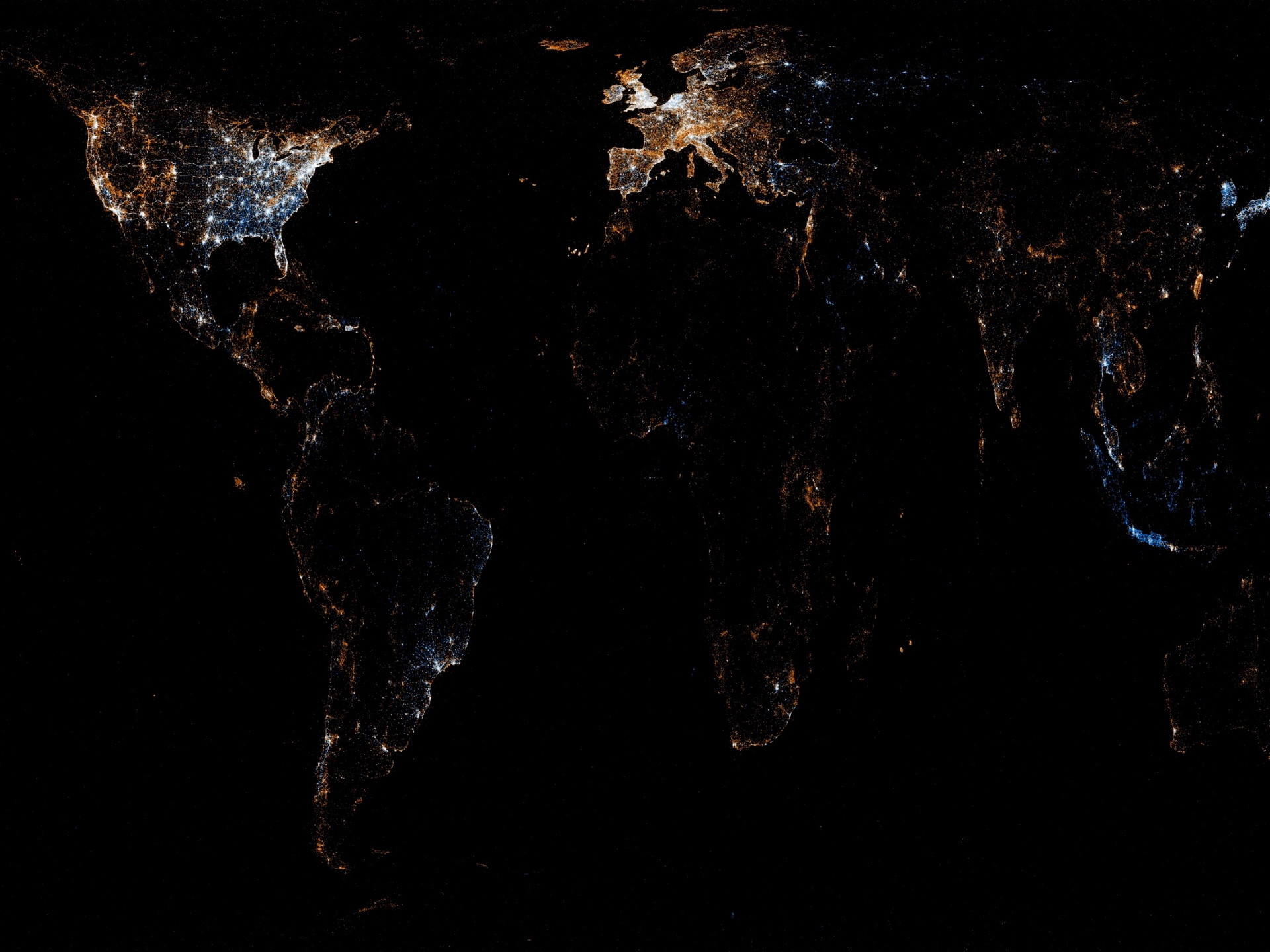
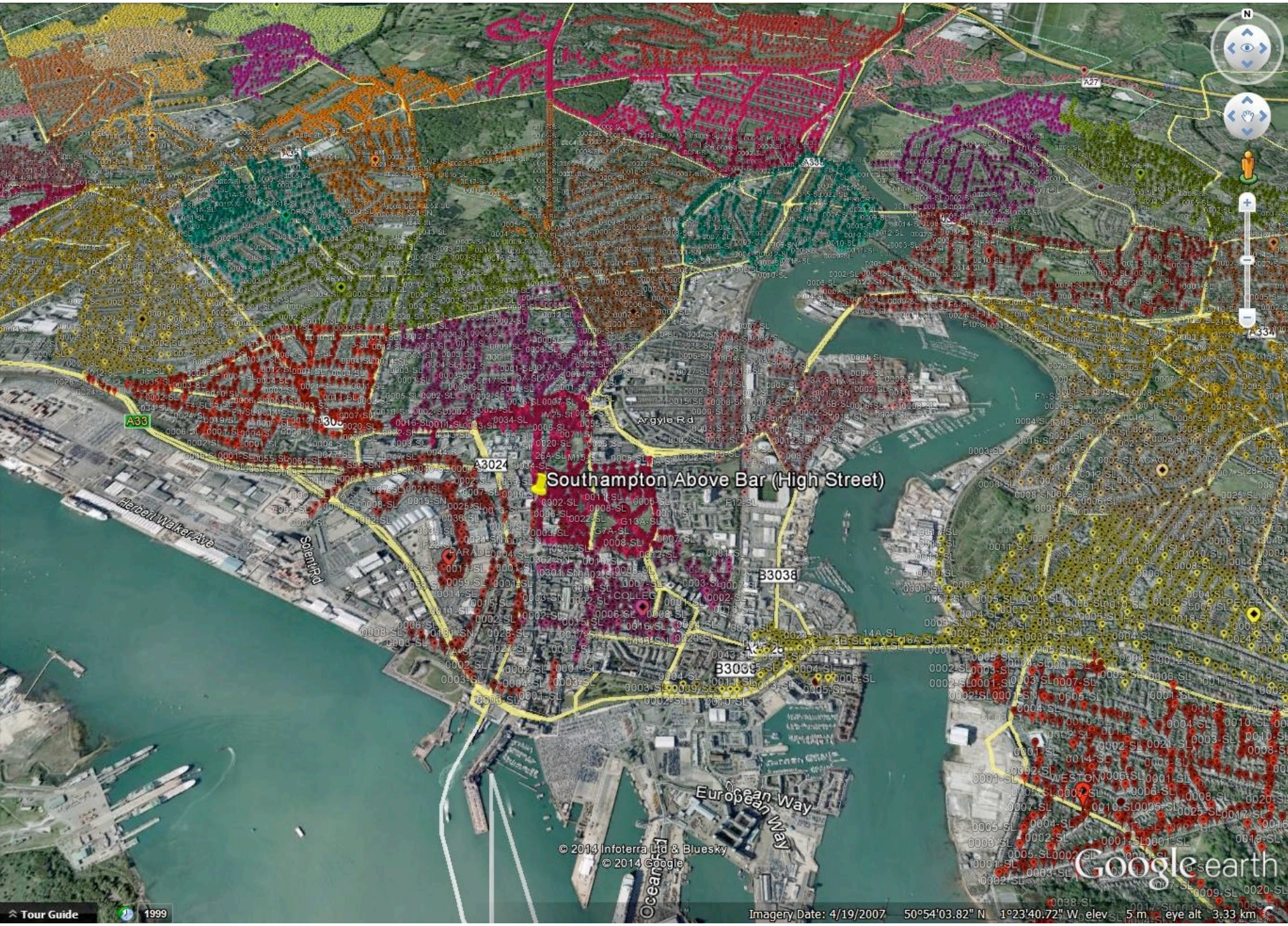
Why (or what) Networks?

(really..?)

Images:
https://www.meetingsbooker.com/images/blog/dreamhack-conference.jpg
https://www.telcoantennas.com.au/site/sites/default/files/imagecache/product_full/cat-6-unshielded-ethernet-lan-cables_5.png
http://www.spcf.edu.ph/wp-content/uploads/wifi-logo.png




Southampton Above Bar (High Street)
Argyle Rd
Herbert Walker Ave
Solent Rd
A33
A3024
B3038
European Way
Ocean Rd
A27
A35
A334
© 2014 Infoterra Ltd & Bluesky
© 2014 Google
Google earth
Tour Guide
1999
Imagery Date: 4/19/2007 50°54'03.82" N 1°23'40.72" W elev 5 m eye alt 3.33 km

mayflower system components

node

ZigBee node

ballast

independent

SubMaster

coordinator

3G modem

light sensors

©TTP 2015

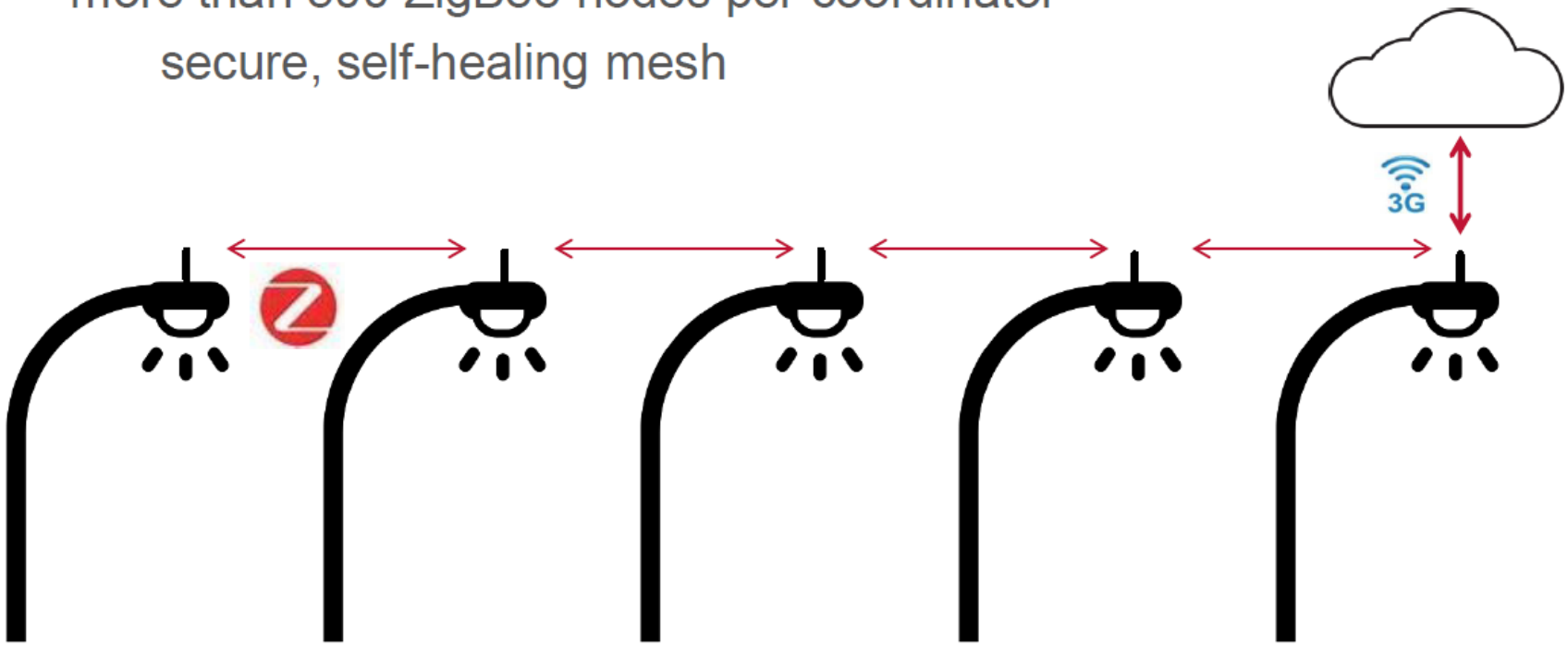
mayflower mesh radio

radio architecture

3G modem provides connection to the cloud

more than 500 ZigBee nodes per coordinator

secure, self-healing mesh



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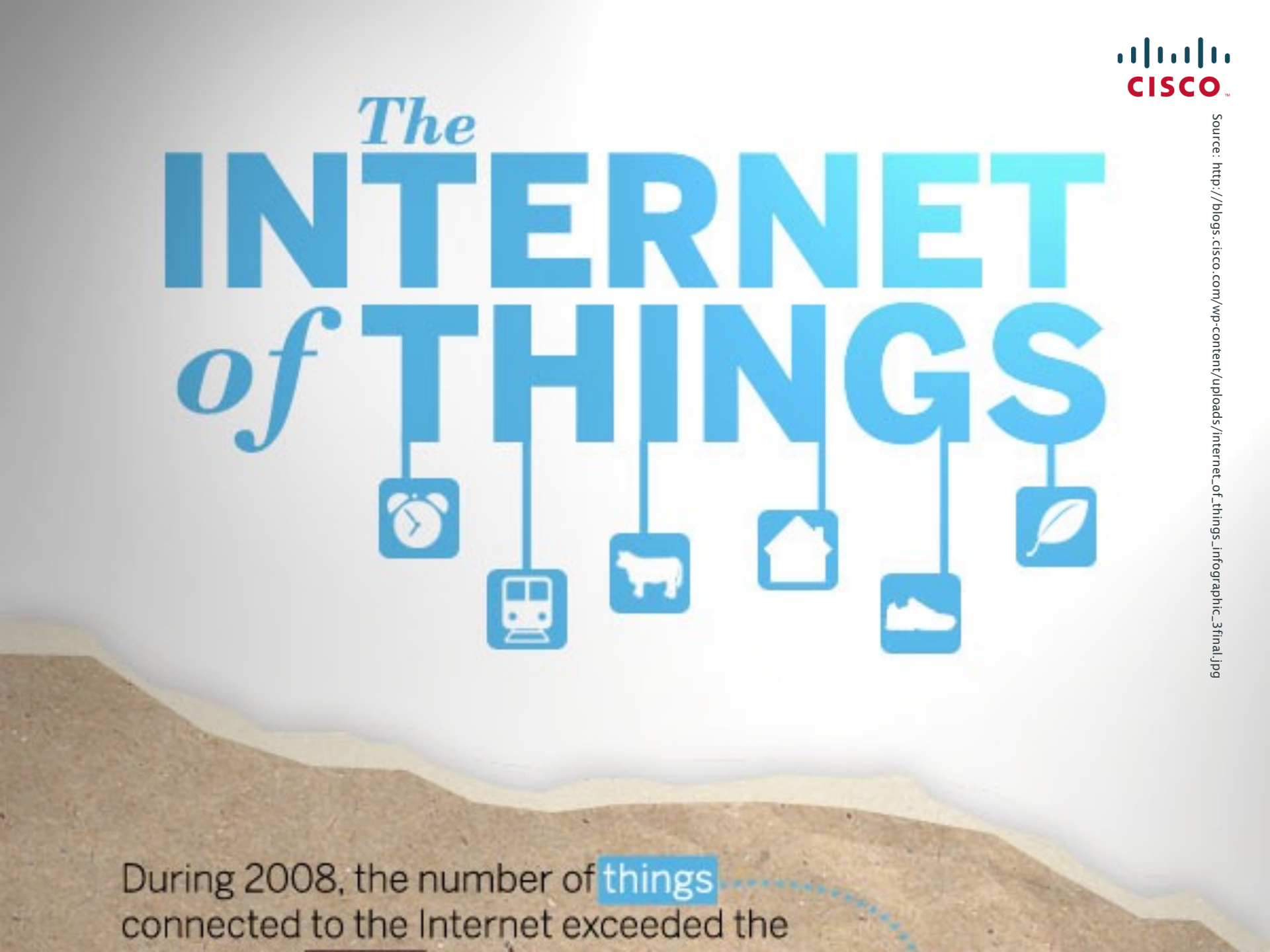
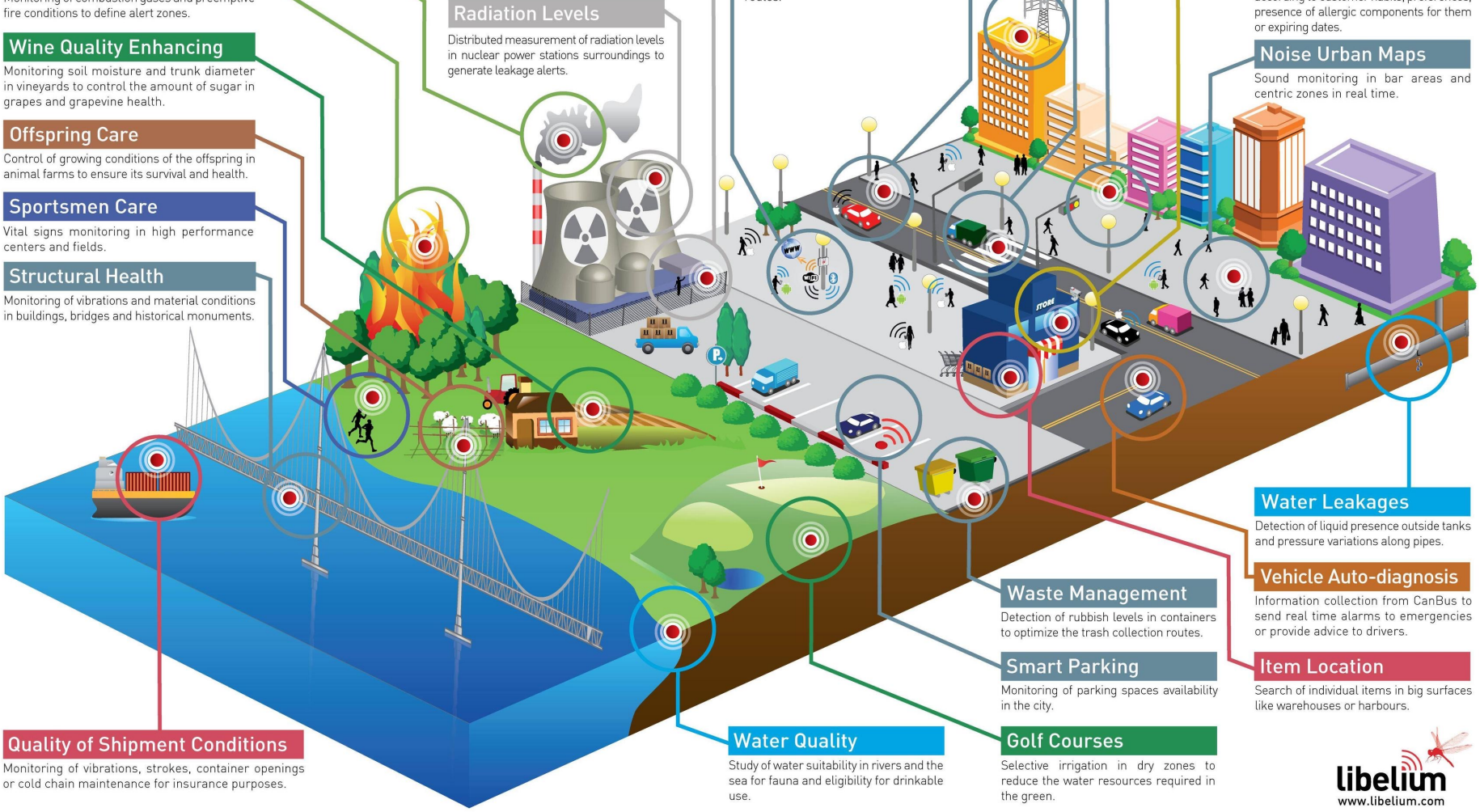


Source: http://blogs.cisco.com/wp-content/uploads/internet_of_things_infographic_3final.jpg

Libelium Smart World



Air Pollution
Control of CO_2 emissions of factories, pollution emitted by cars and toxic gases generated in farms.

Forest Fire Detection
Monitoring of combustion gases and preemptive fire conditions to define alert zones.

Wine Quality Enhancing
Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

Offspring Care
Control of growing conditions of the offspring in animal farms to ensure its survival and health.

Sportsmen Care
Vital signs monitoring in high performance centers and fields.

Structural Health
Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

Quality of Shipment Conditions
Monitoring of vibrations, strokes, container openings or cold chain maintenance for insurance purposes.

Smartphones Detection
Detect iPhone and Android devices and in general any device which works with Wifi or Bluetooth interfaces.

Perimeter Access Control
Access control to restricted areas and detection of people in non-authorized areas.

Radiation Levels
Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.

Electromagnetic Levels
Measurement of the energy radiated by cell stations and and WiFi routers.

Traffic Congestion
Monitoring of vehicles and pedestrian affluence to optimize driving and walking routes.

Smart Roads
Warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

Smart Lighting
Intelligent and weather adaptive lighting in street lights.

Intelligent Shopping
Getting advices in the point of sale according to customer habits, preferences, presence of allergic components for them or expiring dates.

Noise Urban Maps
Sound monitoring in bar areas and centric zones in real time.

Water Leakages
Detection of liquid presence outside tanks and pressure variations along pipes.

Vehicle Auto-diagnosis
Information collection from CanBus to send real time alarms to emergencies or provide advice to drivers.

Waste Management
Detection of rubbish levels in containers to optimize the trash collection routes.

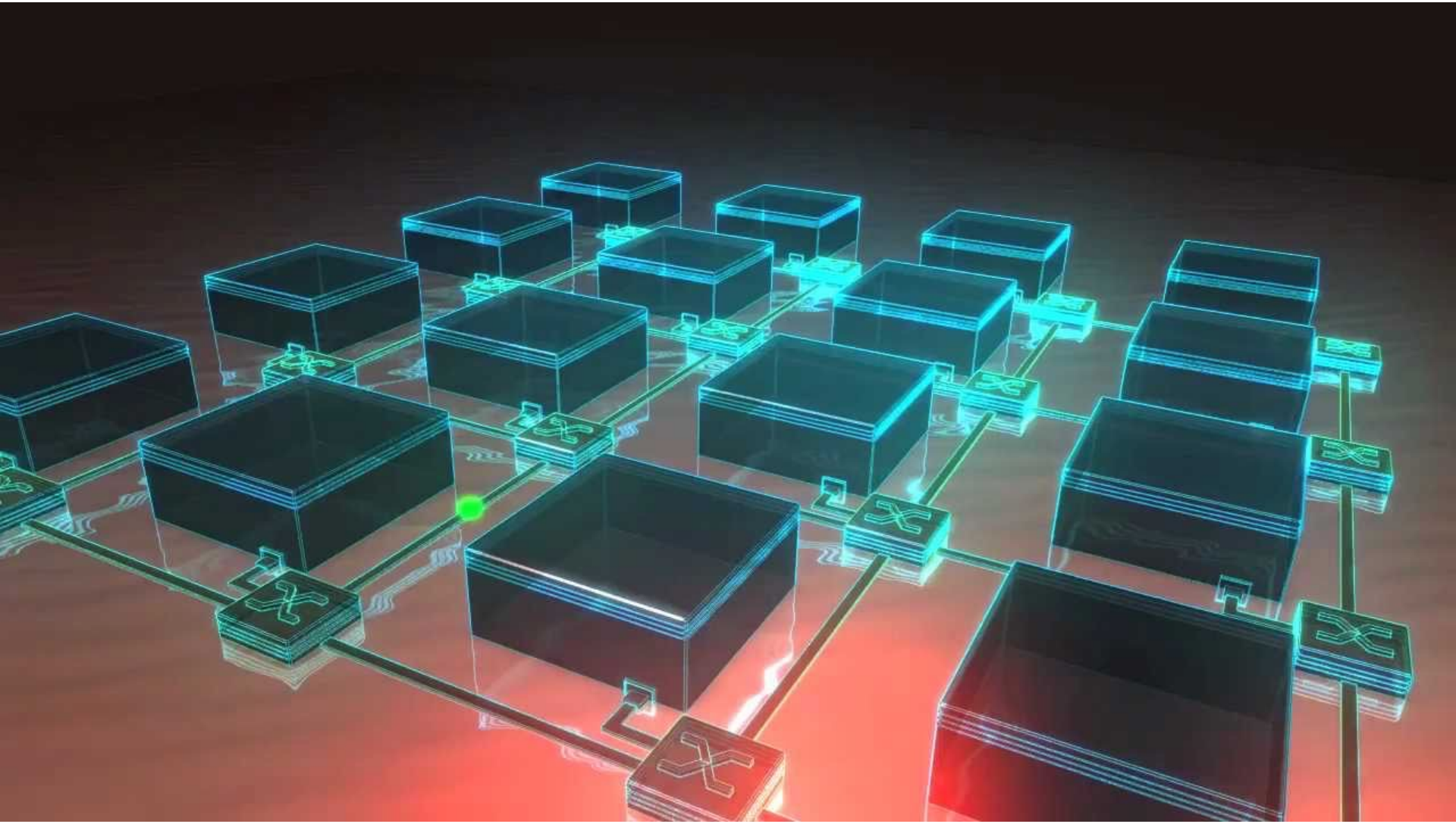
Smart Parking
Monitoring of parking spaces availability in the city.

Item Location
Search of individual items in big surfaces like warehouses or harbours.

Water Quality
Study of water suitability in rivers and the sea for fauna and eligibility for drinkable use.

Golf Courses
Selective irrigation in dry zones to reduce the water resources required in the green.

libelium
www.libelium.com



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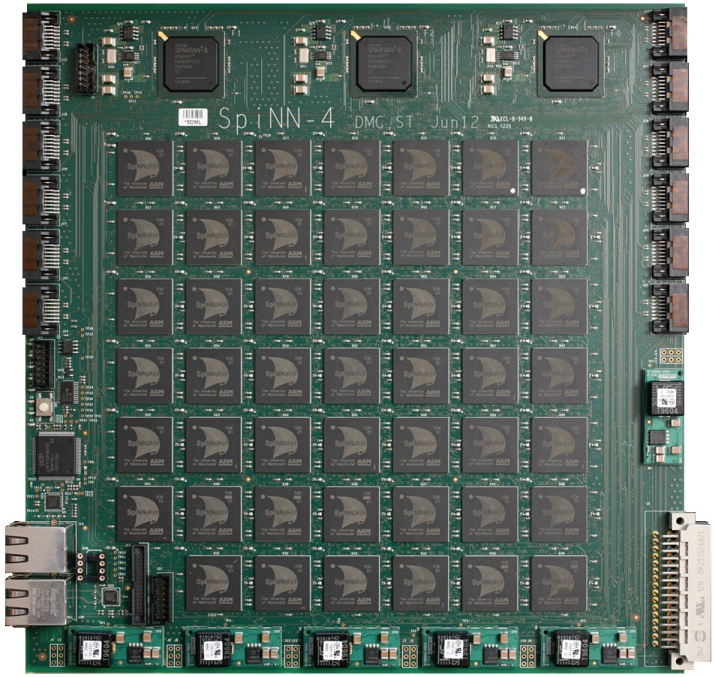

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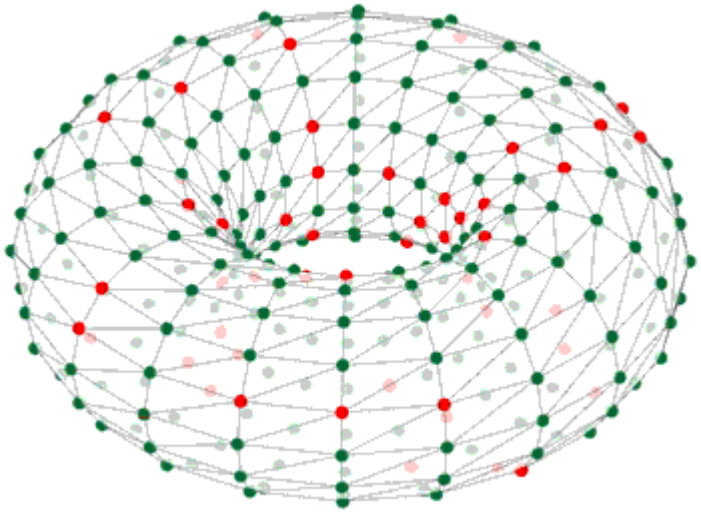

Image: http://apt.cs.manchester.ac.uk/Images/Rotating_Doughnut_S2.gif

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Layered Protocols

and services, interfaces, architectures, reference models...

Protocol Layering

- Example…

- The protocol at each different layers serves a different purpose

  (*or provides a different service*)

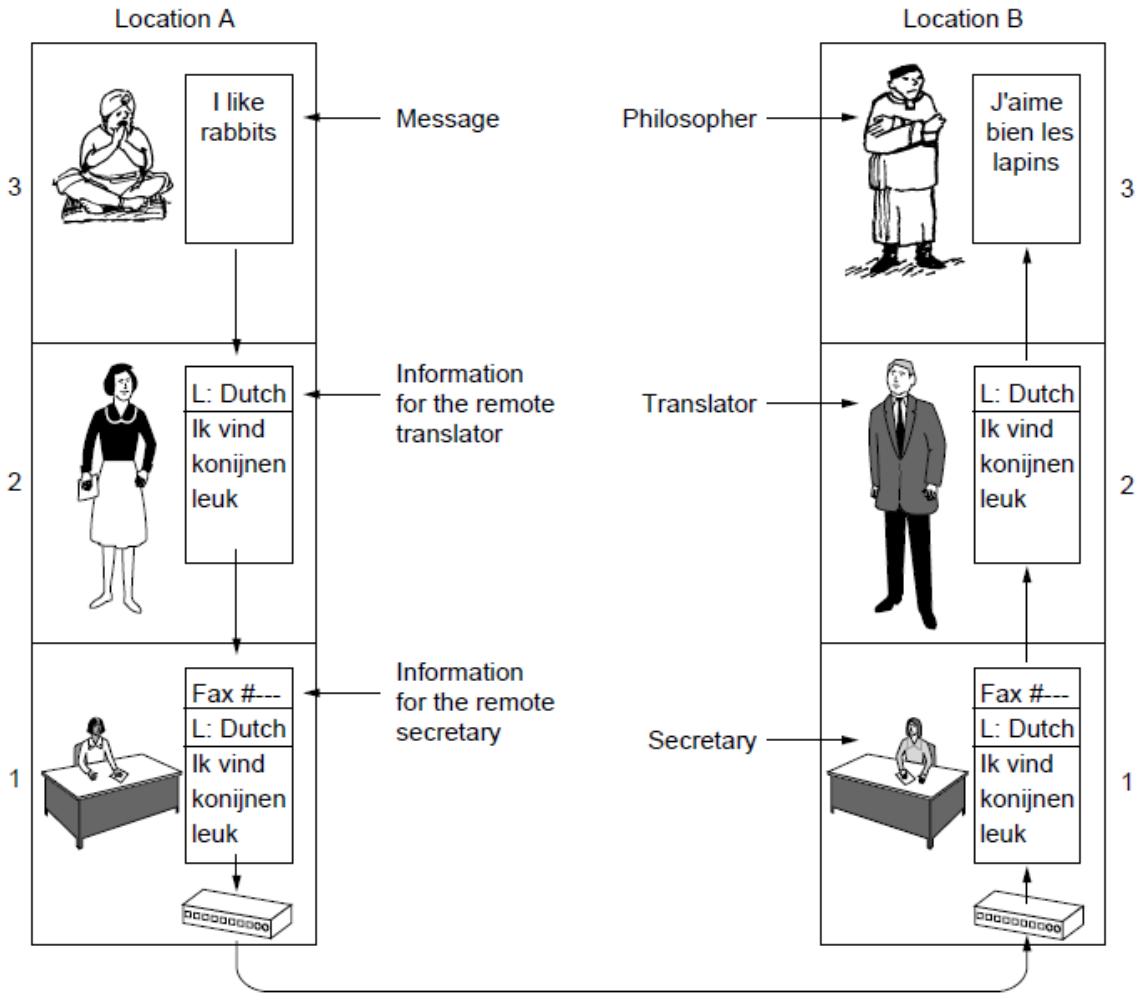
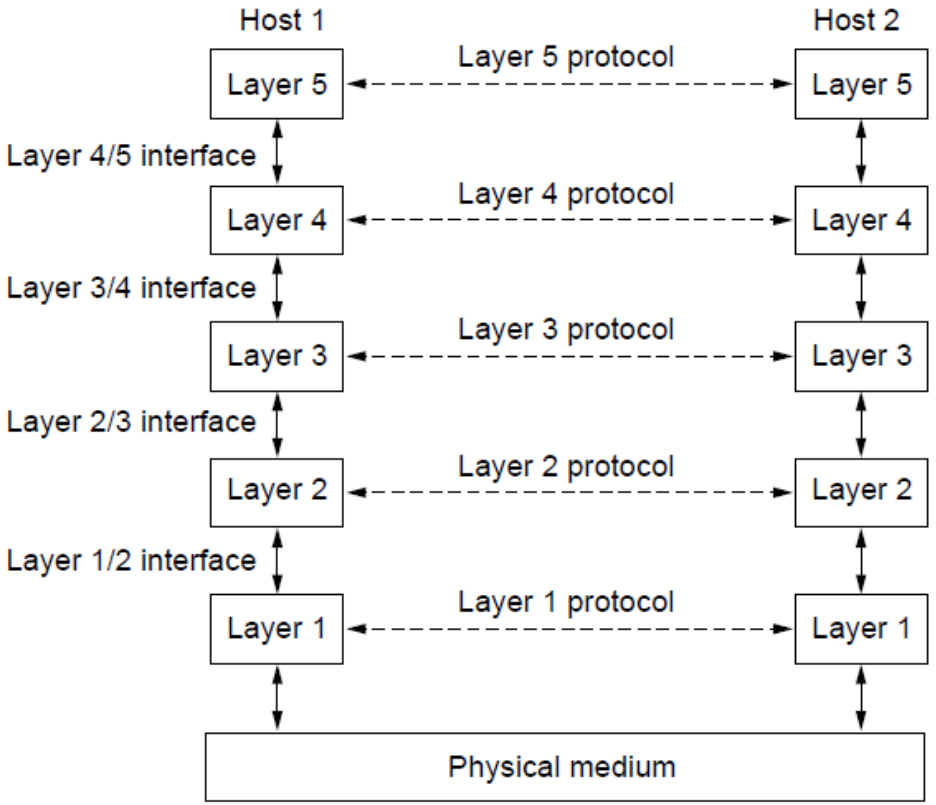


Image: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

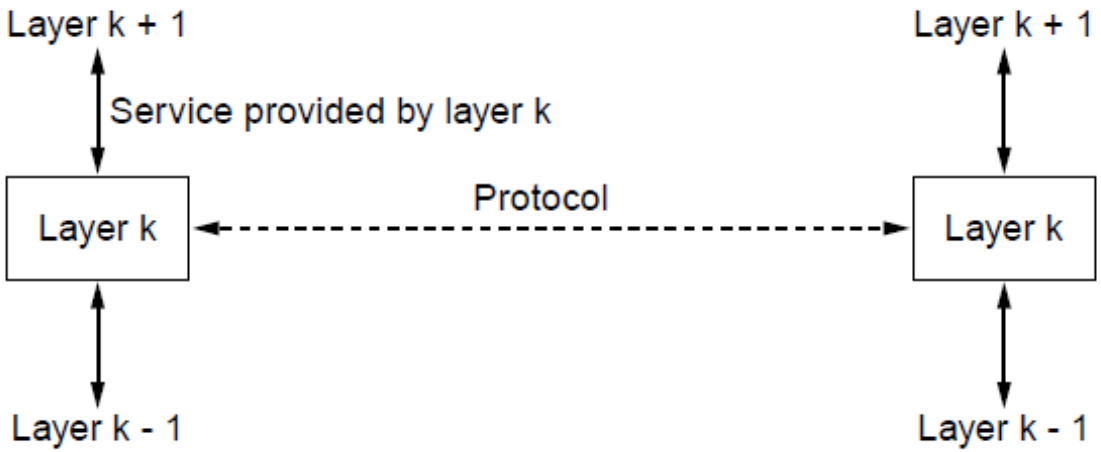
Protocol Layering

- Protocol layering is the main structuring method used to divide up network functionality.
- Each protocol instance talks virtually to its peer
- Each layer communicates only by using the one below
- Lower layer services are accessed by an interface
- At bottom, messages are carried by the medium
- We'll come back to what the layers are and how they're divided later on…



Relationship of Services to Protocols

- A layer provides a service to the one above [vertical]
- A layer talks to its peer using a protocol [horizontal]



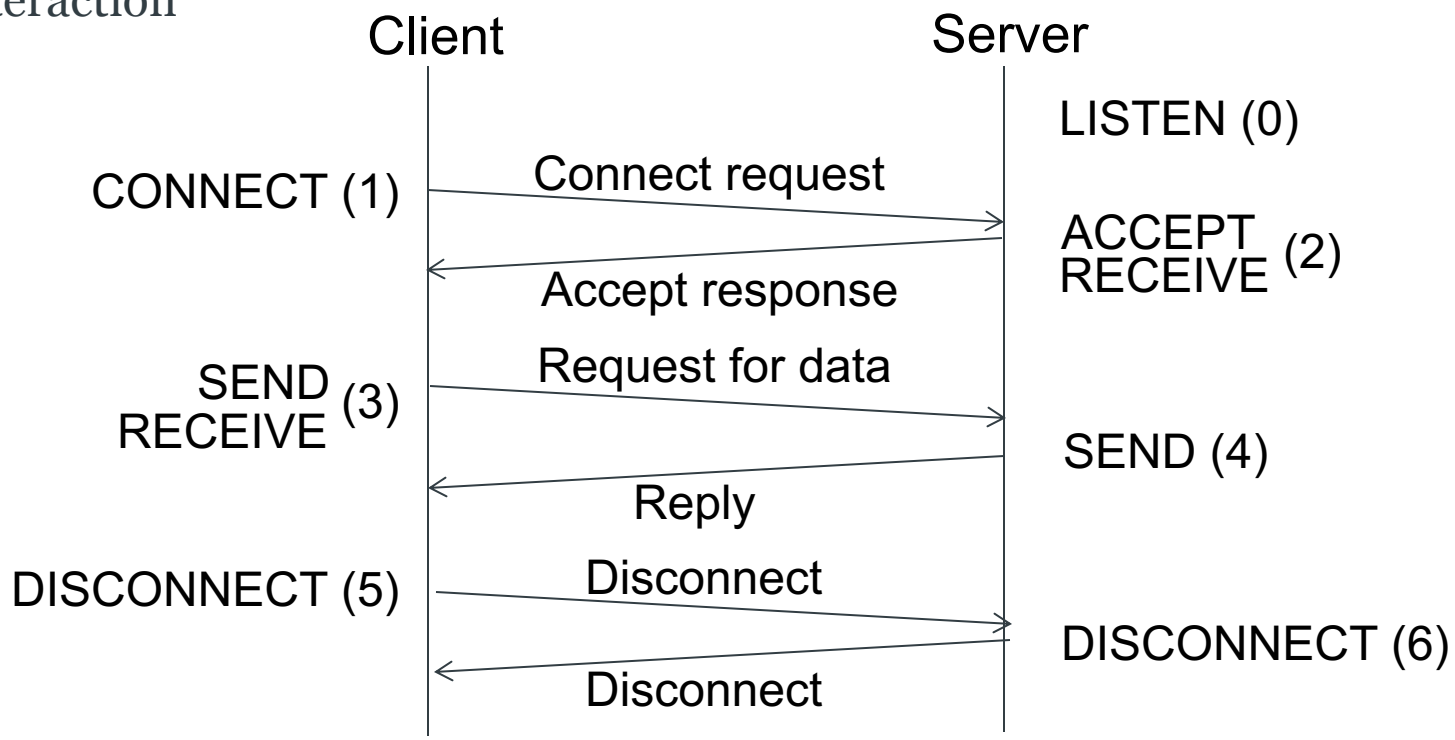
Service Primitives

- A service is provided to the layer above as primitives
- Hypothetical example of service primitives that may provide a reliable byte stream (connection-oriented) service:

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

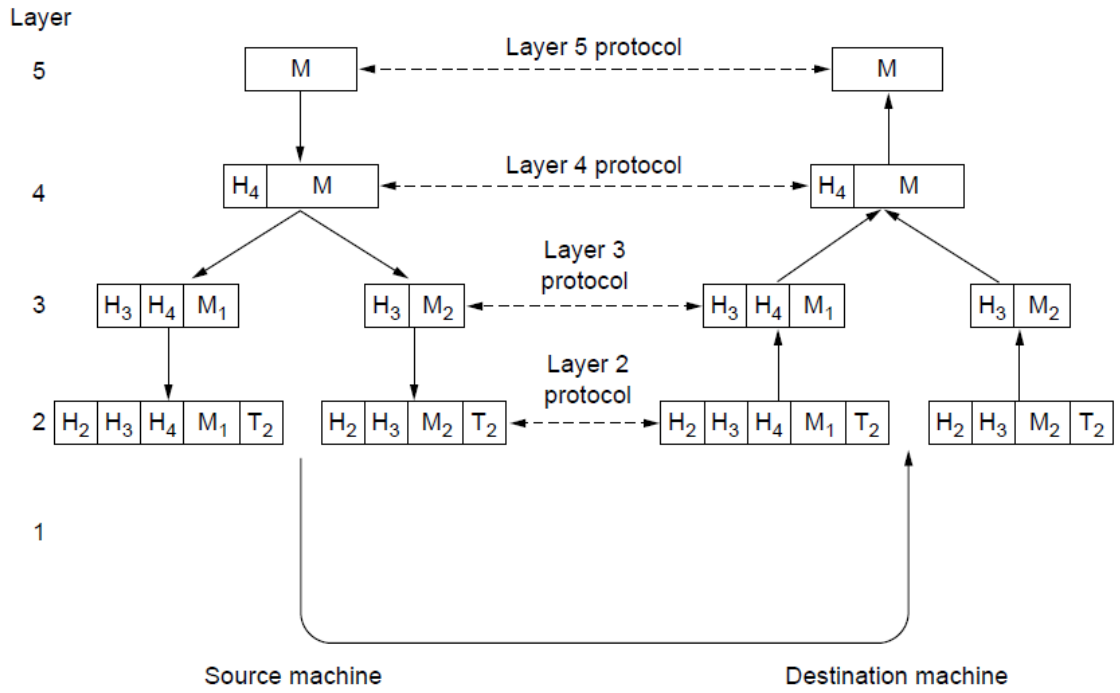
Service Primitives

- Hypothetical example of how these primitives may be used for a client-server interaction



Protocol Layers

- Each lower layer adds its own header (with control information) to the message to transmit and removes it on receive



- Layers may also split and join messages, etc.

Design Issues

- Computer networks have to address the following design issues (and more):
  - Reliability: error detection and correction
  - Packet routing
  - Addressing and naming
  - Internetworking
  - Scalability
  - Congestion and flow control
  - Throughput, latency and QoS management
  - Confidentiality and authentication

- This module will look at where and how these are addressed in the protocol layers

Connection-oriented vs Connectionless Service

- Connection-oriented service
  - A connection is negotiated and setup, and released when finished.
  - Provides a communication 'tube', and manages flow through it.
  - May provide a reliable or unreliable service:
    - Reliable: file transfers
    - Unreliable: VoIP/video conferencing
- Connectionless service
  - 'Messages' are sent without establishing a connection
  - Messages may be received out of order
  - May provide a reliable or unreliable service:
    - Reliable: acknowledged datagram (e.g. an SMS)
    - Unreliable: unacknowledged datagram (send and hope!)

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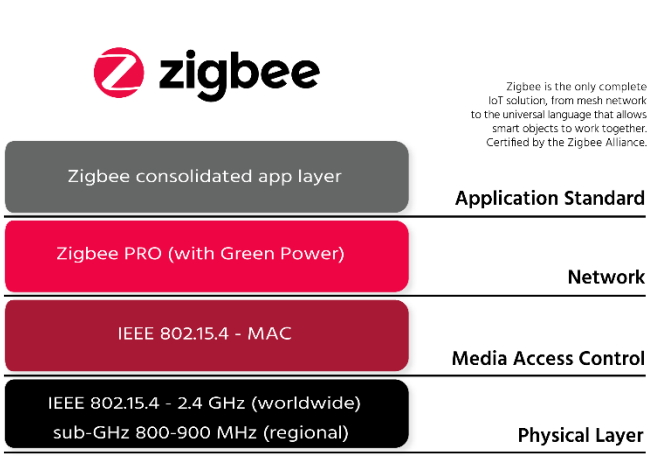
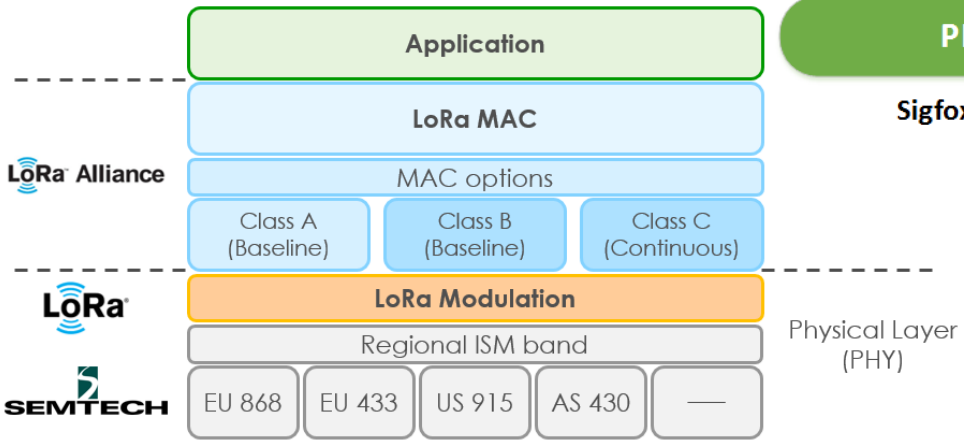
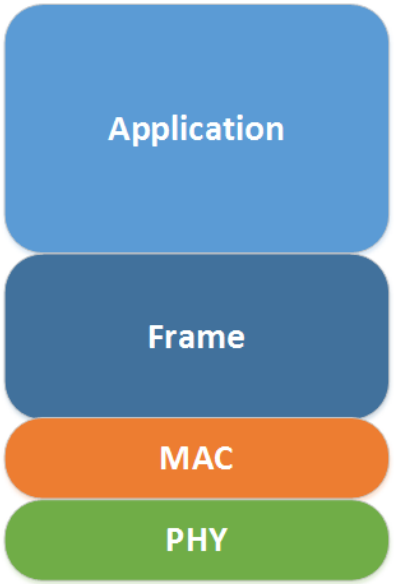
Reference Models

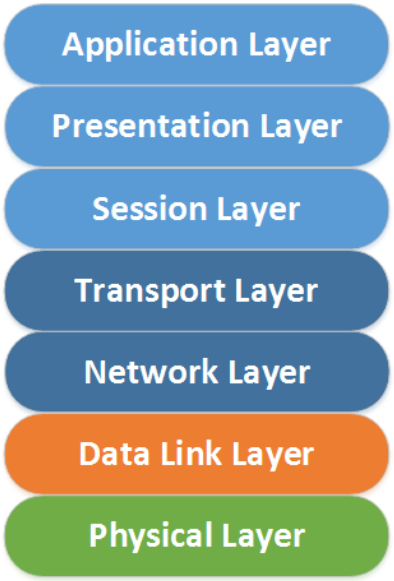
Example Protocol Stacks







Sigfox Stack



OSI Stack

Reference Models

- We will consider three:
  - The OSI Reference Model
  - The TCP/IP Reference Model
  - Model used in Tanenbaum (*which we'll use too*)
  - We'll come back and look at other protocol stacks later in the module

OSI Reference Model

- Created by the International Standards Organization (ISO) in 1983
- The Open Systems Interconnection (OSI) reference model is/was a principled, international standard to connect different systems, consisting of 7 layers.

- A layer is used where a different abstraction is needed
- Each layer provides a well-defined function
- Layer boundaries are chosen to minimize information flow across interfaces
- A balance in the number of layers is made such that
  - distinct functions aren't thrown together
  - there aren't an unwieldy number of layers

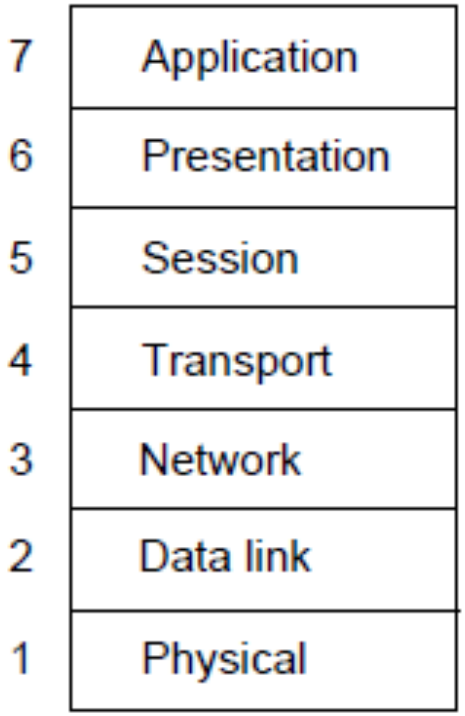


Figure: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

OSI Reference Model

7	Application	– Provides functions needed by users
6	Presentation	– Converts different representations
5	Session	– Manages task dialogs
4	Transport	– Provides end-to-end delivery
3	Network	– Sends packets over multiple links
2	Data link	– Sends frames of information
1	Physical	– Sends bits as signals

Figure: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

OSI Reference Model

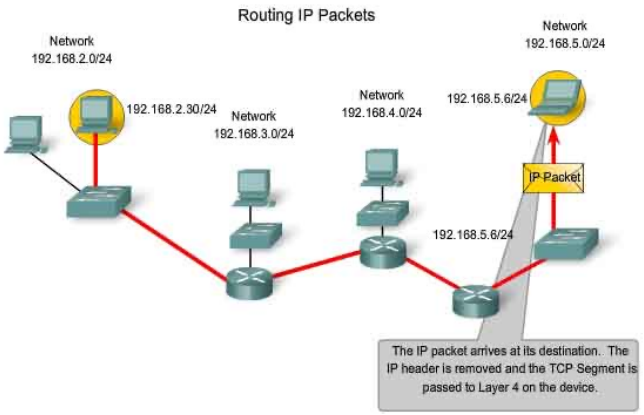


Image: http://www.highteck.net/images/87-IP-routing.jpg

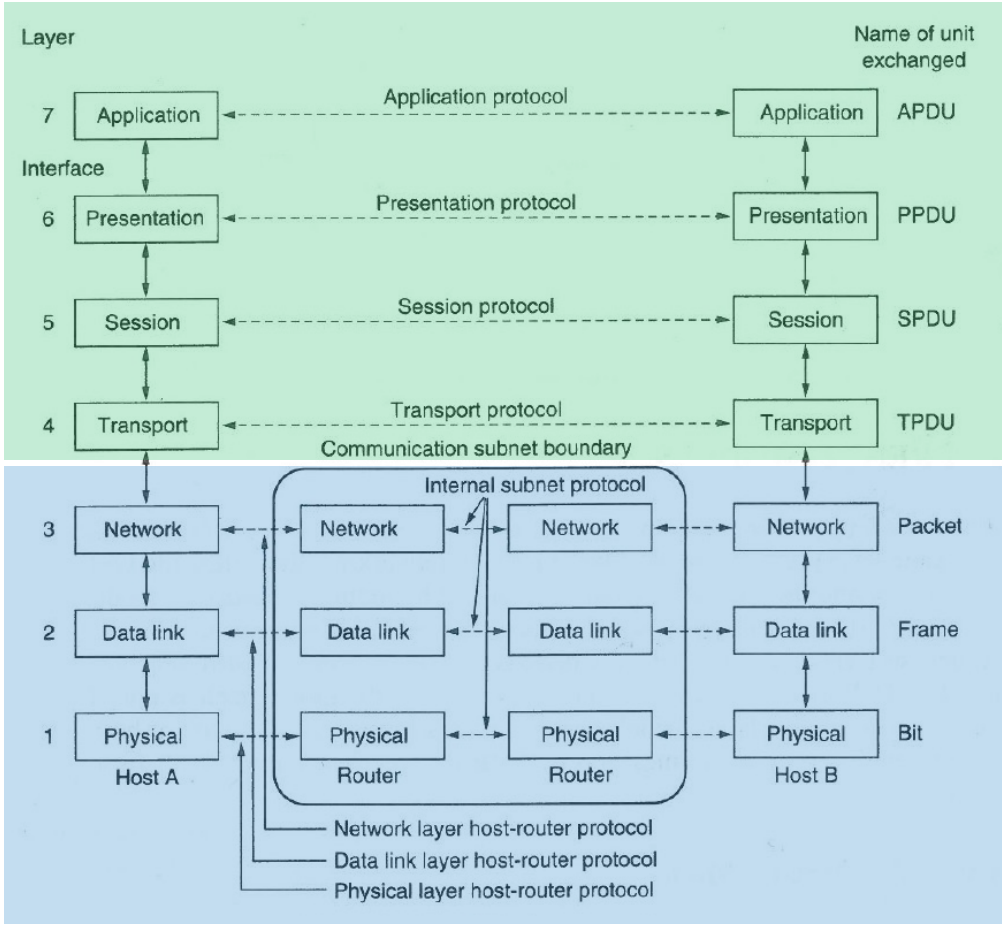


Image: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

OSI Reference Model

+ Very influential model with clear concepts
+ Excellent tool for understanding networks (and hence appears in most textbooks) *but can be safely ignored, because…*
- Model created first, then protocols designed to fit (hence unforeseen shortcomings – for example, no support for internetworking: it was assumed that each country would only have one network, and it would be running the OSI protocols!)
- Only supports connection-oriented communication in the transport layer (supports connectionless and connection-oriented in the network layer) – the user doesn't get a choice
- Complex models and protocols led to bad implementations, hence gained a reputation for being poor quality
- Viewed as being pushed by the government
- Doesn't map well to TCP/IP

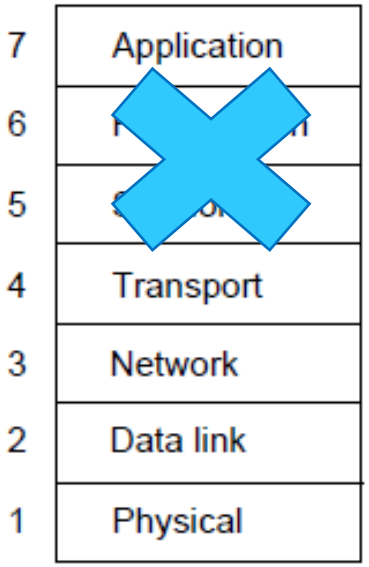


Image: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

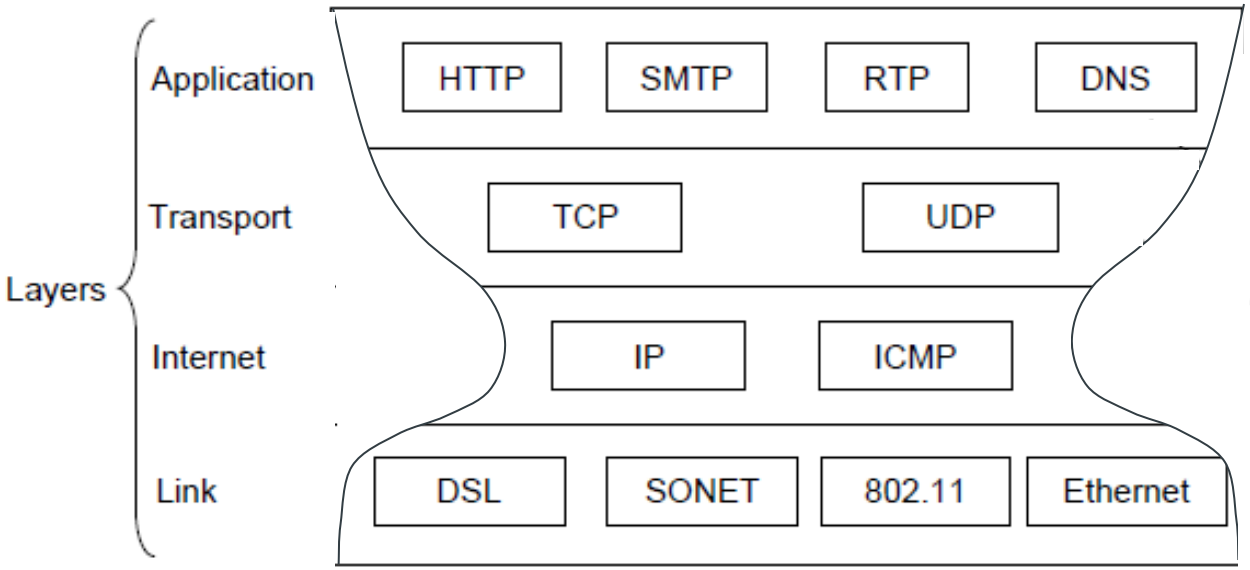
TCP/IP Reference Model

- TCP/IP (Transmission Control Protocol over Internet Protocol)
- Important: forms the basis of the Internet!

- US DoD supported the ARPANET project to connect university and government sites using leased telephone lines.
- When satellite and radio links were later added, existing protocols weren't sufficient, and TCP/IP was born. Required:
  - Seamless internetworking
  - Resilience
  - Flexibility

- Led to a packet-switching network based on a connectionless layer which runs across different networks (IP).

TCP/IP Reference Model



IP is the "narrow waist" of the Internet

Protocols are shown in their respective layers

Figure: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

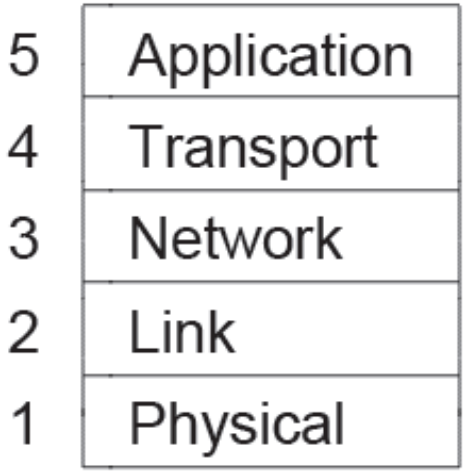
TCP/IP Reference Model

+ Gained widespread use (before the OSI Reference Model was announced)
+ Had good early implementations
+ Supports connectionless and connection-oriented communication in the transport layer (but only supports connection-oriented communication in the network layer) - gives the user the choice
- Not really a model, just a description of existing protocols!
- Fits TCP/IP (perfectly), but nothing else very well!
- Doesn't define services, interfaces and protocols – hence not useful as a guide for designing new technologies

Image: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

Model Used in Tanenbaum/ELEC3227/ELEC6255

- It is based on the TCP/IP model but we pull out the physical layer and look beyond Internet protocols.



Programs that make use of the network. Doesn't include the UI (e.g. web browser), but the portion that uses the network

Strengthens the delivery guarantees of the Network layer providing increased reliability (e.g. TCP)

How to combine multiple links into networks, and networks of networks into internetworks. Includes finding paths (routing) (e.g. IP)

How to send finite length messages between directly connected computers with specified levels of reliability (e.g. Ethernet or 802.11)

How to transmit bits across different kinds of media

Standardisation

- Standards:
  - Increase the
  - Lead to mas
- Standards do:
  - define what
  - dictate the p
- Standards don't
  - define how
  - specify the s
- Some standards ('de-facto') come after the invention
- Other standards ('de-jure') come about from official formal bodies

Body	Area	Examples
ITU	Telecommunications	G.992, ADSL H.264, MPEG4
IEEE	Communications	802.3, Ethernet 802.11, WiFi
IETF	Internet	RFC 2616, HTTP/1.1 RFC 1034/1035, DNS
W3C	Web	HTML5 standard CSS standard

Figure: CN5E by Tanenbaum & Wetherall, © Pearson Education-Prentice Hall and D. Wetherall, 2011

Definitions

Definitions

- Computer Network — *a collection of autonomous computers interconnected (they can exchange information) by a single technology.*
- Internetwork — *multiple networks joined together.*
- Service — *defines the functionality a layer provides, i.e. the semantics*
- Interface — *defines the operations and services the low layer makes to the upper one*
- Protocol — *an agreement between communicating parties on how communication is to proceed*
- Protocol Stack — *a list of the protocols used by a certain system, with one protocol per layer*
- Network Architecture — *a set of layers and protocols, e.g. the Internet*

Metric Units

- Capitalisation of prefixes
  - For units >1 (e.g. mega, giga, peta), capitalise the symbol
    - e.g. **M**b, **G**b, **P**b
  - For units <1 (e.g. milli, nano, pico), don't capitalise the symbol
    - e.g. **m**bps, **n**bps, **p**bps (*probably not used so often!*)
  - **kbps** (kilo bits per second) is considered an exception to this rule
- Units
  - B = bytes; b = bits
    - e.g. M**B** = megabytes; m**b** = millibits
- Powers of 2 or 10 in prefixes?
  - Usually, prefix units use powers of 10
    - e.g. 1 kbps = 10^3 (1000) bps
  - However, storage (disk, memory, file, database etc) traditionally uses powers of 2
    - e.g. 1 kB = 2^10 (1024) bytes

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The Physical Layer

The Physical Layer

- Concerned with how to communicate raw bits over a physical communication channel
  - e.g. a wired (coaxial/optical) or wireless (radio/satellite) channel
  - Bit representation, timing, pins/wires etc

- ELEDC3227 students
  - Most of your existing modules on communications were related to this layer.
- ELEC6255 students
  - You'll have some lectures and a lab on this later in the module

- We'll look at some more 'practical' aspects of the physical layer later on

Example Questions

ELEC3222 18/19

In the context of computer networking, **define** the terms:

1. Service;
2. Interface;
3. Protocol.

ELEC3227/ELEC6255 19/20

In the context of networking systems, **define** the terms *protocol layering* and *standardisation*.

Explain one advantage and one disadvantage of each.

Similar questions in ELEC3222 15/16 and 17/18

ELEC3222 16/17

Computer networks typically use protocol layering.

An algorithm that is used to implement a service provided by one of the layers is changed.

Explain how this impacts the operation of the layers above and below.

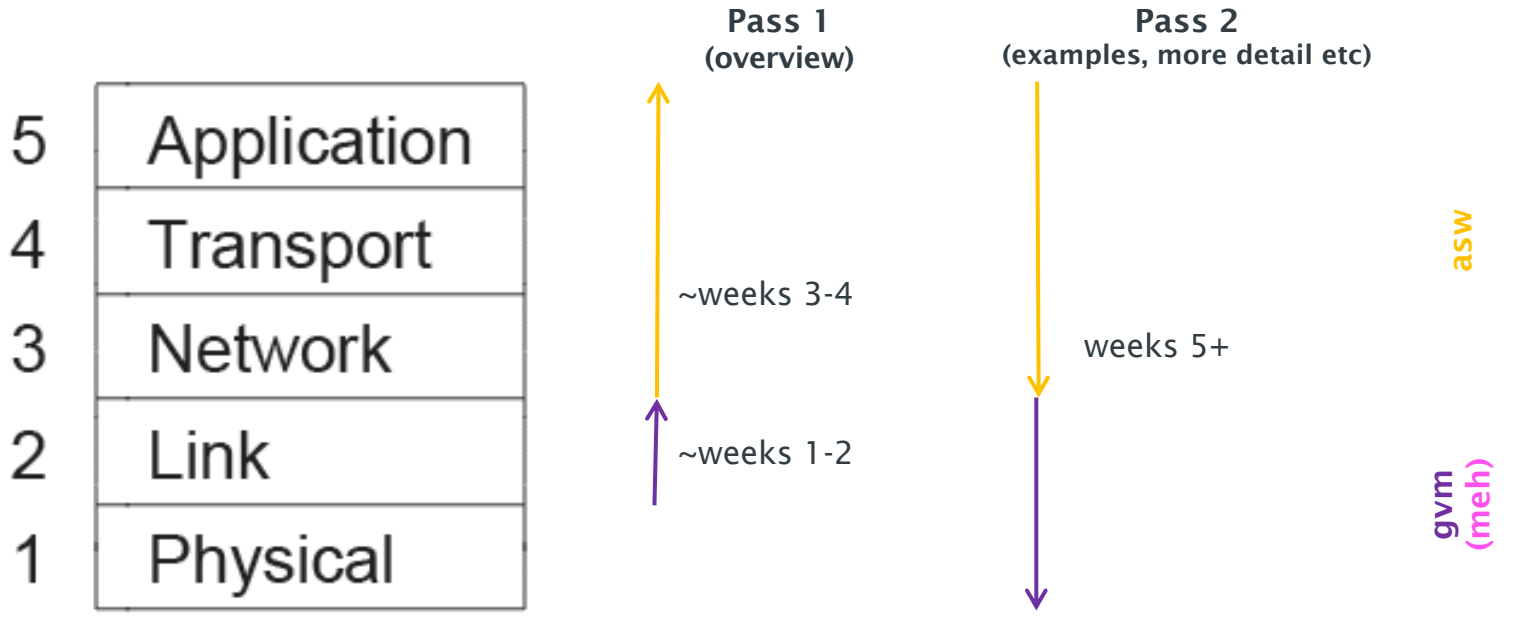
The Schedule for these Modules

(revisted...)

List of Topics

- Network architectures and principles
- Physical networks and their design
- Layered networking models:
  - Physical layer principles and protocols (ELEC6255)
  - Data link layer principles and protocols
  - Network layer principles and protocols
  - Transport layer principles and protocols
  - Application layer principles and protocols
- Example protocols and architectures
- Network-on-chip protocols (ELEC3227)
- Energy and power efficiency (ELEC3227)
- Network security
- Emerging network technologies
- Network simulation (ELEC6255)

Lecture Schedule



Questions?