Week 7: Transport Layer

Lecturer: Tom Drummond

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Introduction to Instructor

Prof Tom Drummond

Since June 2021: Melbourne Connect Chair of Digital Innovation for Society

From 2010-2021: Prof at Monash University

(2016-2021 Head of Depa ter Systems Engineering)

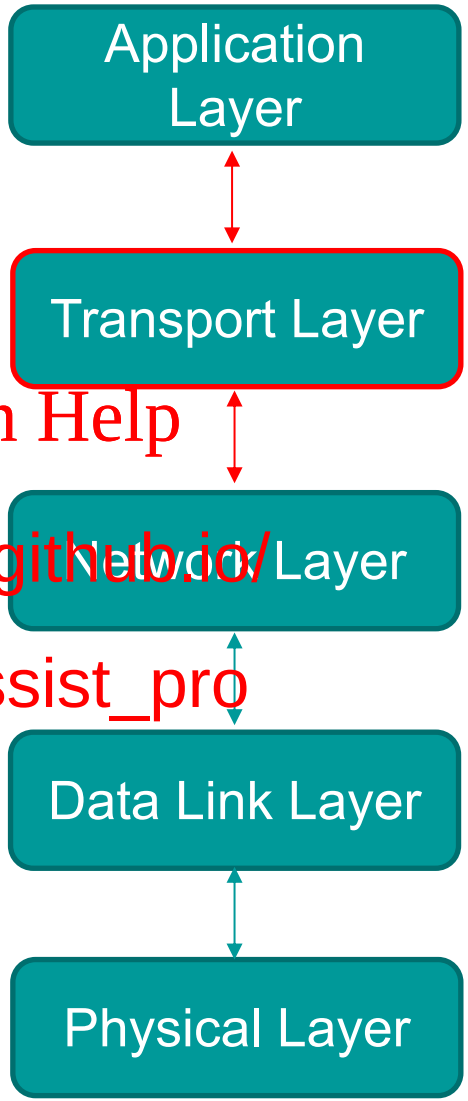
2008-2010 Lecturer in Information Engineerin of Cambridge

2004-2008 PhD at Curtin University (Perth, WA)

1985-1988 BA Mathematics, University of Cambridge

Areas of Interest: Computer Vision, Robotics, Machine Learning

Layered Network



Tom

Transport Layer Function

- Main function
  - provide **efficient, reliable, & cost-effective data tran** **the processes in the app** physical or data network **pendent** of

- Recall: To Achieve this
  - It calls services provided by the network layer

Transport Layer Services

- Transport Layer Services provide interfaces between the Application Layer and the Network Layer
- Transport Entities (the hardware or software which actually does the work) can exist in multiple locations:
- **Where and w ut sometimes is)?**
  - OS kernel
  - System library (library package twork applications)
- Not so much…
  - User process
  - Network interface card

Services Contd.

- Transport layer adds **reliability** to the network layer
  - Offers connectionless (e.g., UDP) in addition to connection-oriented (e.g, TCP) services to applications
- Relationship between network, transport and application layers:

Transport Layer and Network Layer Services Compared

- **If Transport and Network layers are so similar, why are there two layers?**
- Transport layer code runs entirely on hosts, Network lay ntirely on routers…..
- ***Users have no real con the network*** layer – Transport layer: we can improve QoS
- Transport layer ***fixes reliability problems*** caused by the Network layer (e.g., delayed, lost or duplicated packets)

Position of the Transport Layer

- The Transport Layer occupies a key position in the layer hierarchy because it clearly delineates
  - ***providers*** of data transmissions services
    - at the network, data link, and physical layers
  - ***users*** of reli services
    - at the appli
- In particular, ***users*** ***connection-oriented transport services*** for a reliable service on top of an unreliable network

Example:

Your First Network (Pseudo)Code

```
Socket A_Socket = createSocket("TCP");
connect(A
send(A_socket, “My first m
disconnect(A_socket);
```


… there is also a server component for this client that runs on another host…

Features of a *Simple* Transport Layer

- Abstraction and primitives provide a simpler API for application developers independent of network layer

Transport Layer Encapsulation

- Abstract representation of messages sent to and from transport entities
  - Transport Protocol Data Unit (TPDU)
- Encapsulation r units to network layer units (to f s)

Segment

Transport Service Primitives/ Segments

- Primitives that applications might call to transport data for a simple connection-oriented service:
  - Server executes LISTEN
  - Client executes CONNECT
    - Sends CONNECTION REQUEST TPDU to Server
    - Receives CONNECTION ACCEPTED TPDU to Client
  - Data exchanged
  - Either party exec

Segment

Simple Connection Illustrated

- Solid lines (right) show client state sequence
- Dashed lines (left) show server state sequence
- Transitions in italics are due to segment arrivals

Elements of Transport Protocols

- Connection establishment
- Connection release
- Address

Connection Establishment in the Real World

- When networks can lose, store and duplicate packets, connection establishment can be complicated
  - congested networks may delay acknowledg
  - incurring repeated multipl sions
  - any of which may not arri out of sequence – delayed duplicates
  - applications degenerate with such congestion (eg. imagine duplication of bank withdrawals)

Reliable Connection Establishment

- Key challenge is to ensure reliability even though packets may be lost, corrupted, delayed, and duplicated
  - Don't treat an old or duplicate packet as new
  - (Use repe sums for loss/corruption)
- Approach:
  - Don't reuse sequence numbers within maximum segment lifetime
  - Use a sequence number space large enough that it will not wrap, even when sending at full rate
  - Three-way handshake for establishing connection..

Three Way Handshake

- Three-way handshake used for initial packet
  - Since no state from previous co
  - Both hosts c fresh seq. numbers
  - CR = Connect Request

Three Way Handshake Contd.

- Three-way handshake protects against odd cases:

a) Duplicate CR. Spurious ACK does not connect

b) Duplicate CR Same plus D rejected (wrong ACK).