Find Your Group / Table

Last name	First name	Group
Aasbø	Felix Leon Johnsen	6B
Ackerman	Maan	1A
Ådlandsvik	Jonathan Ward	6A
Alhajeed	Suha	2A
Bækken	Frida Nordnes	3A
Bang-Olsen	Andreas Isegran	8A
Berwari	Kurdin Bekes	2A
Bjørkum	Hans Skirstad	8B
Borch	Christian Uteng	5A
Bratsvedal	Adam Paalsrud	6B
Cincovic	Leon	1A
Dalbye	Karin Ingrid Marie	4A
Flatberg	Odin	9B
Gerhardsen	Trym Silsand	8B
Gulljord	Kaisa	5A
Håkonsen	Sondre Songedal	8A
Hansen	Frida Andrea	6A
Hauksson	Daniel Örn	8B
Heggem	Ingrid Grov	7A

Last name	First name	Group
Hegre	Torjus Meyer	1A
Helgesen	Sander	9B
Henriksen	Daniel	2A
Iden	Erika	8A
Jægersborg-Iversen	Olav	3B
Johansen	Justine Sønsteli	9A
Korterud	Jacob Weldingh	7A
Lervik	Liv Barstad	1B
Lutnæs	Tørres	5B
Makhtari	Mohand	9A
Melsnes	Maria Olsen	2B
Migliorini	Mika Gabriel Holst	5B
Mosfjell	Jonathan	1B
Muruganandan	Anarththan Achshathan	3A
Myrland	Viktor	4B
Nguyen	Christoffer Hoang	3B
Ommundsen	Kristoffer Sørli	9A
Opdøl	Oskar	1B

Last name	First name	Group
Paheerathan	Rithaann	4B
Pettersen	Henrik	4A
Rian	Tobias	7A
Robstad	William	7B
Rosvoldaunet	Annika Olaussen	7B
Sævareid	Olav Onstad	7B
Salte	Sigrid	4B
Skjerve	Eskil Andreas Kjønstad	3A
Sonerud	Mina Kibsgård	5B
Torp	Sindre André Svendsrud	2B
Trælandshei	Jørgen	6A
Udnæs	Andrea Charlotte Ribe	6B
Valle	Ole Gustav	9B
Vikingstad	Viktor Westerberg	4A
Vist	Sigrid	3B
Walderhaug-Johnsen	Adrian	2B
Willoch	Caroline	8B
Wittner	Herman	5A

Updated Course Schedule

Uke	Tid	Tema	Faglærer
33	tir.-fre. 9:15	Teknostart	Katrien, Stanislav, Tjerand, Poul
34	Fredag 8:15-14:00	Lab 1: Linux CLI	Stanislav
35	Fredag 8:15-14:00	Lab 2: IPs, LAN	Stanislav
36	Fredag 8:15-14:00	Lab 3: Ports, Web Servers	Stanislav
37	Fredag 8:15-14:00	Lab 4: Routing, DNS	Stanislav
38	Fredag 8:15-14:00	Lab 5: Om Teamarbeid, Lab report 1 due on Friday, Sep. 20th	Katrien
39	Fredag 8:15-14:00	Lab 6: Bærekraft (kun forelesning 8:15-10:00)	Iwona
40	Fredag 8:15-10:00	Lab 7: Cybersikkerhet 1: Intro and Ethical Hacking	Basel
41	Fredag 8:15-10:00	TBA	TBA
42	Fredag 8:15-14:00	Lab 8: Cybersikkerhet 2: Information Gathering	Basel
43	Fredag 8:15-14:00	Lab 9: Cybersikkerhet 3: Exploitation	Basel
44	Fredag 8:15-14:00	Lab 10: Introduction to IoT and the Microbit, Lab report 2 due on Friday, Nov. 1st	Arne
45	Fredag 8:15-14:00	Lab 11: Tilstandmaskiner	Arne
46	Fredag 8:15-14:00	Lab 12: HTTP and JSON	Stanislav
47	Fredag 8:15-14:00	Lab 13: MQTT	Tu
48	Fredag 8:15-14:00	Lab report 3 due on Friday, Nov. 29th	

NTNU | Kunnskap for en bedre verden

TTM4175 – Week 36

Networking II

Ports, Layers, Client-Server Architecture, Web Servers

Goals

- Recognize the importance of **ports and layers**
  - Run and interact with a basic web server
  - Investigate the protocol stack
  - Observe HTTP traffic
- Learn basic **Docker** principles
  - Images and containers
  - The Dockerfile
  - Basic commands for managing containers

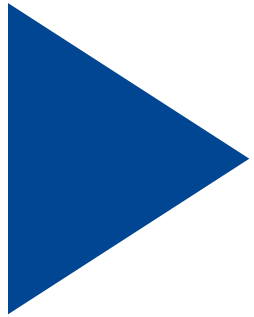
Recap of Preparation Material

Readings

Layered architecture

Network application architectures

Processes communicating



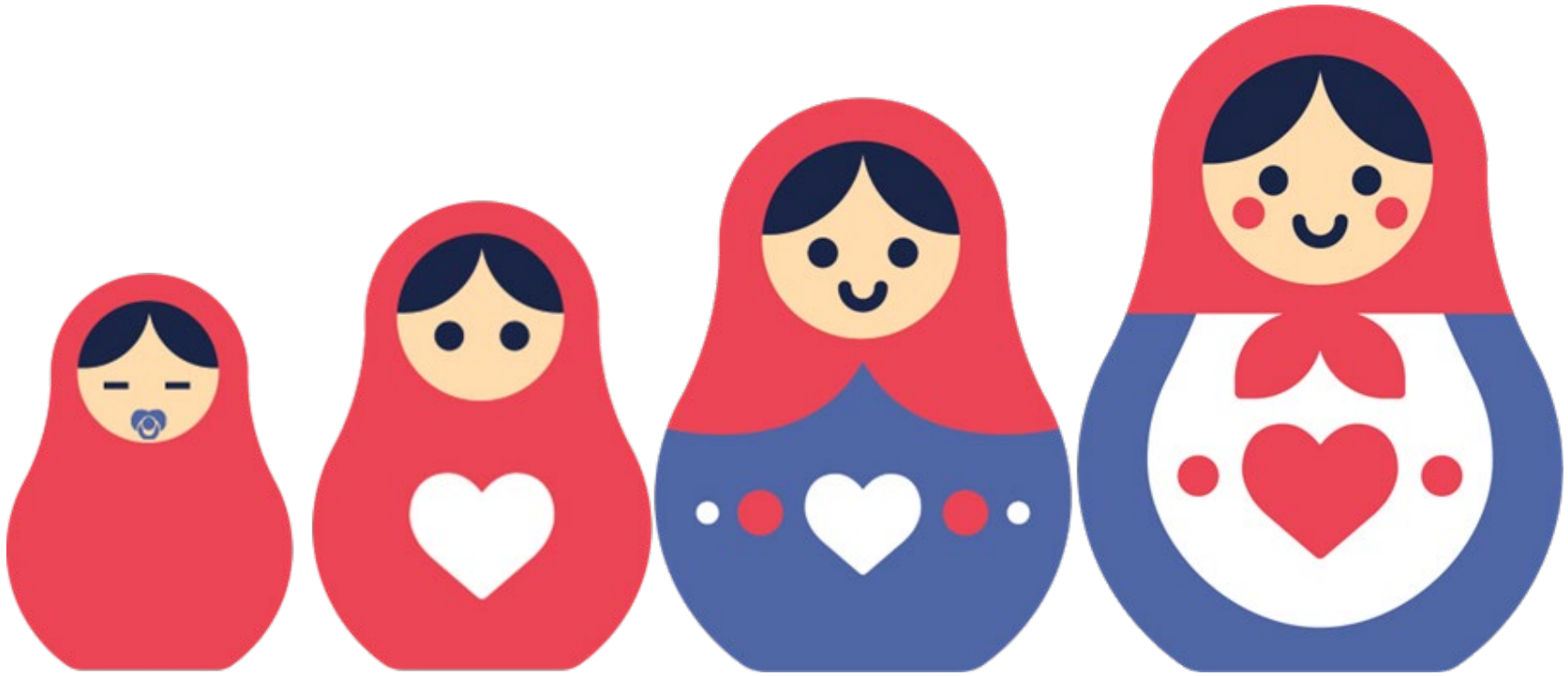
Videos

Client-server architecture

What is a server?

Docker, web servers (optional)

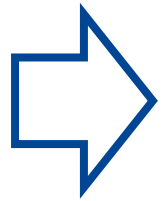
Layers and Encapsulation



Protocol Layers and Reference Models

Networks are complex, with many "pieces"

- Hosts
- Routers
- Links of various media
- Applications
- Protocols
- Hardware, software



Any hope of *organizing* the structure of networks and our discussion of them?

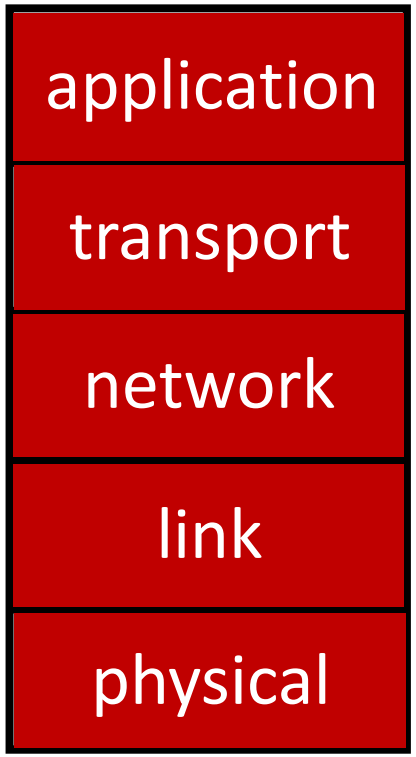
Why Layering?

Approach to designing and discussing complex systems

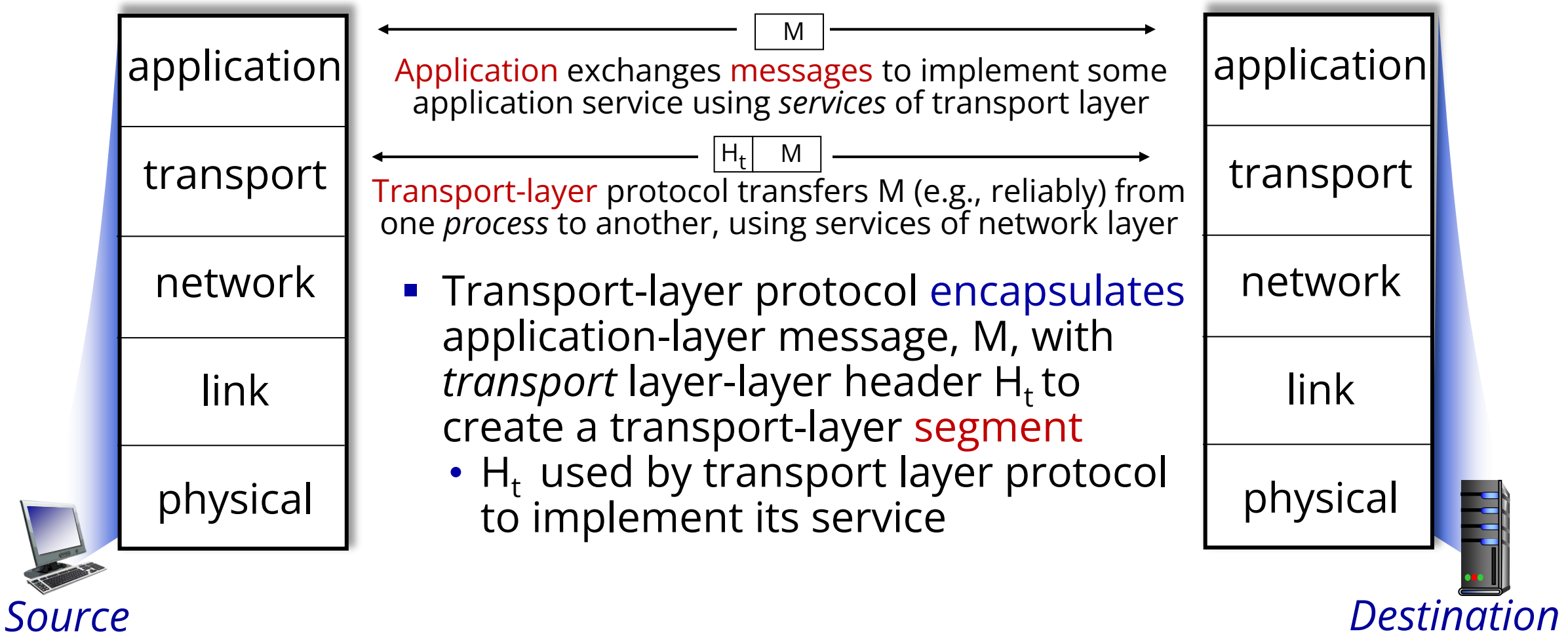
- Explicit structure allows identification, relationship of system's pieces
  - Layered *reference model* for discussion
- Modularization eases maintenance, updating of system
  - Changes in layers' service *implementation* transparent to rest of system
  - Airline example: change in gate procedure doesn't affect rest of system

Layered Internet Protocol Stack

- *Application:* supports network applications
  - HTTP, IMAP, SMTP, DNS, ..
- *Transport:* process-to-process data transfer
  - TCP, UDP
- *Network:* routing of datagrams from source to destination
  - IP, routing protocols
- *Link:* data transfer between neighboring network elements
  - Ethernet, 802.11 (WiFi), PPP
- *Physical:* bits “on the wire”

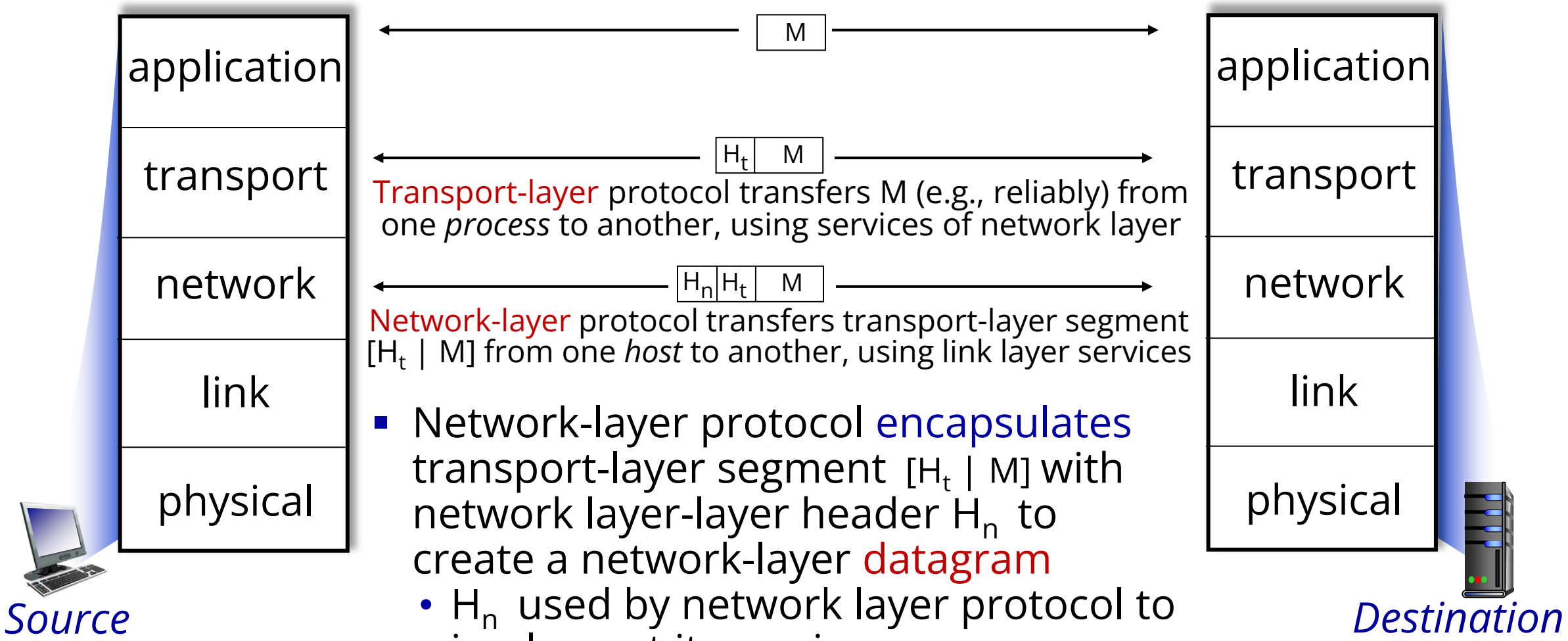


Services, Layering, and Encapsulation



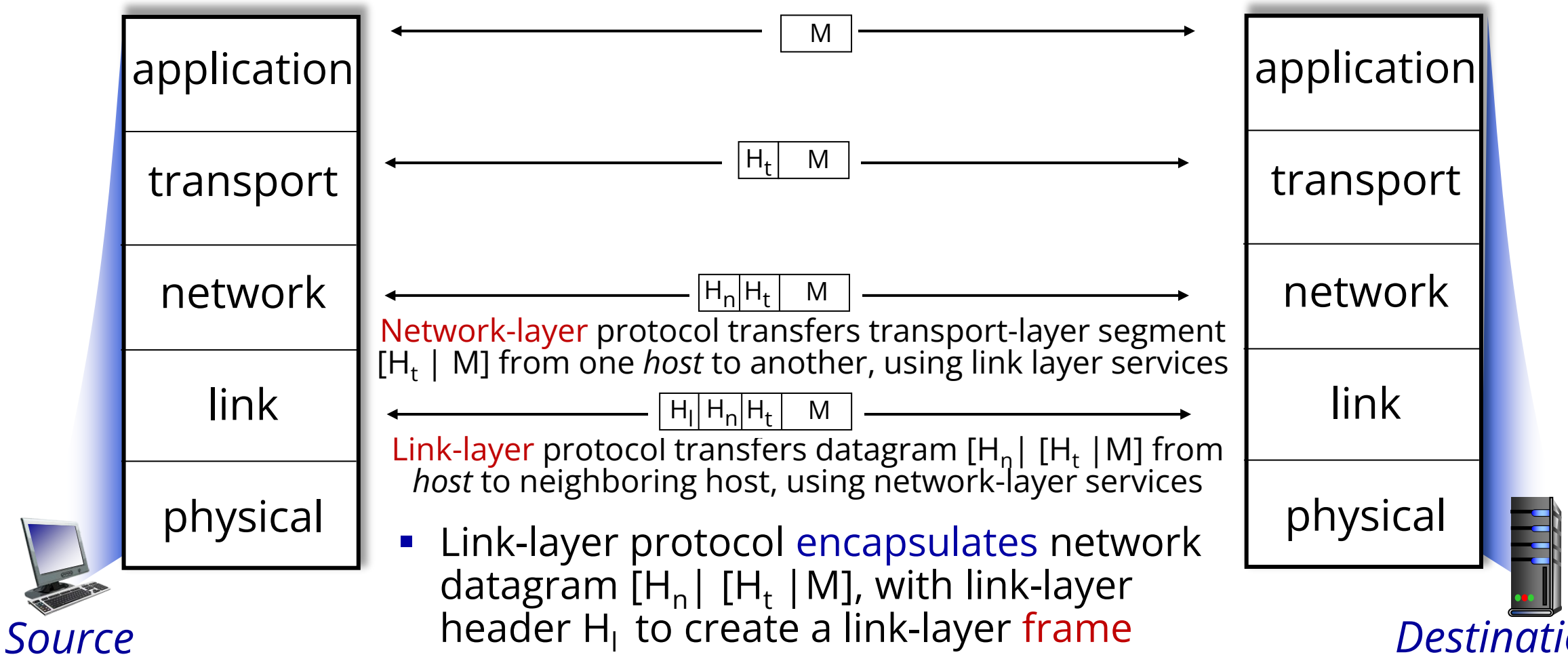
- Transport-layer protocol encapsulates application-layer message, M, with *transport* layer-layer header H_t to create a transport-layer segment
  - H_t used by transport layer protocol to implement its service

Services, Layering, and Encapsulation



- Network-layer protocol encapsulates transport-layer segment [H_t | M] with network layer-layer header H_n to create a network-layer datagram
  - H_n used by network layer protocol to implement its service

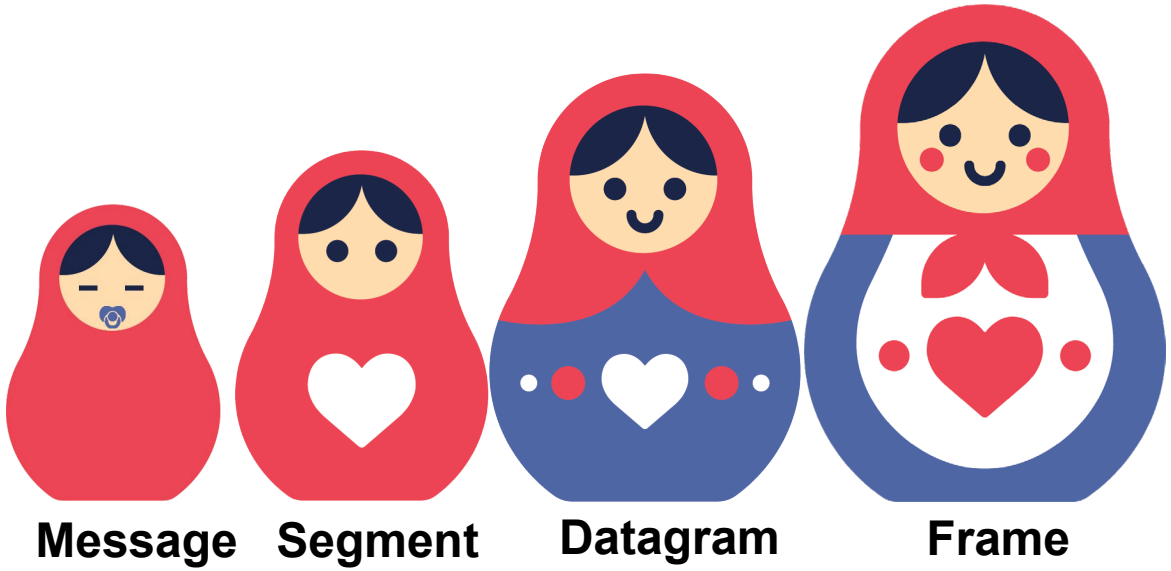
Services, Layering, and Encapsulation



- Link-layer protocol encapsulates network datagram [H_n| [H_t |M], with link-layer header H_l to create a link-layer frame

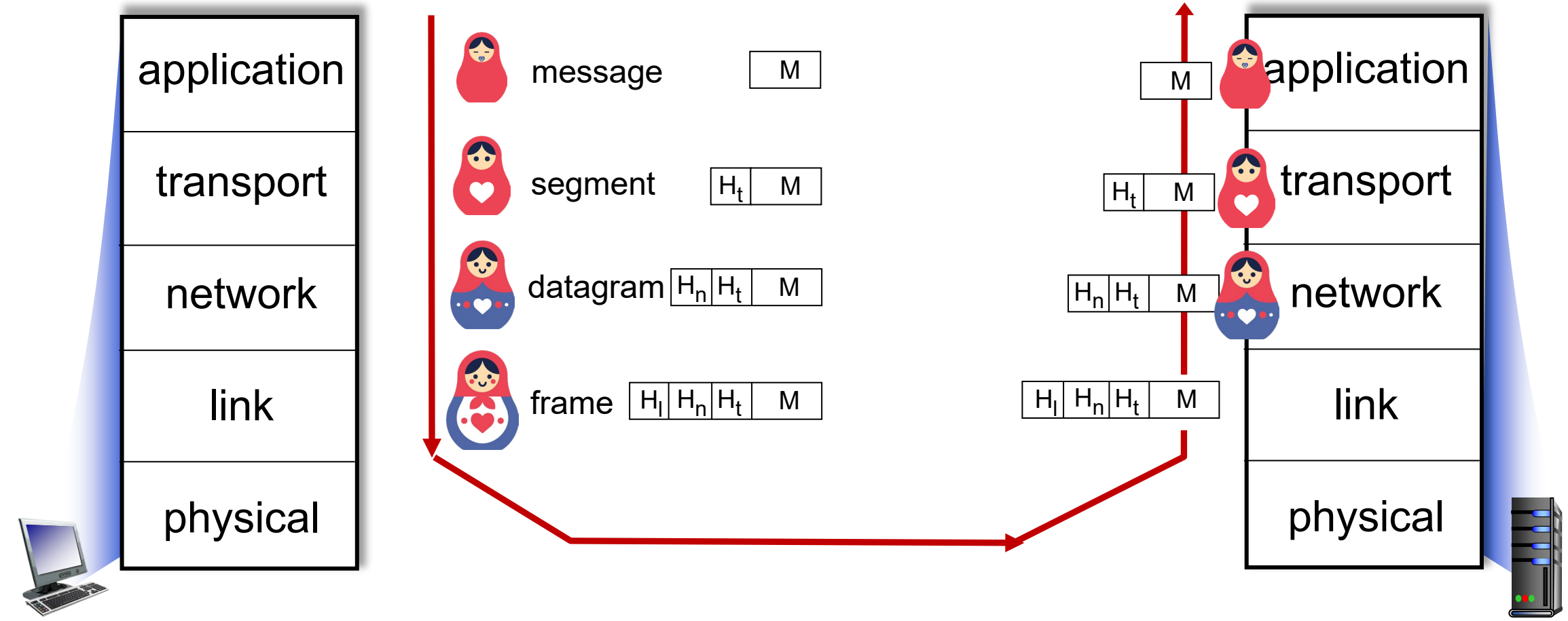
Encapsulation

Matryoshka dolls (stacking dolls)

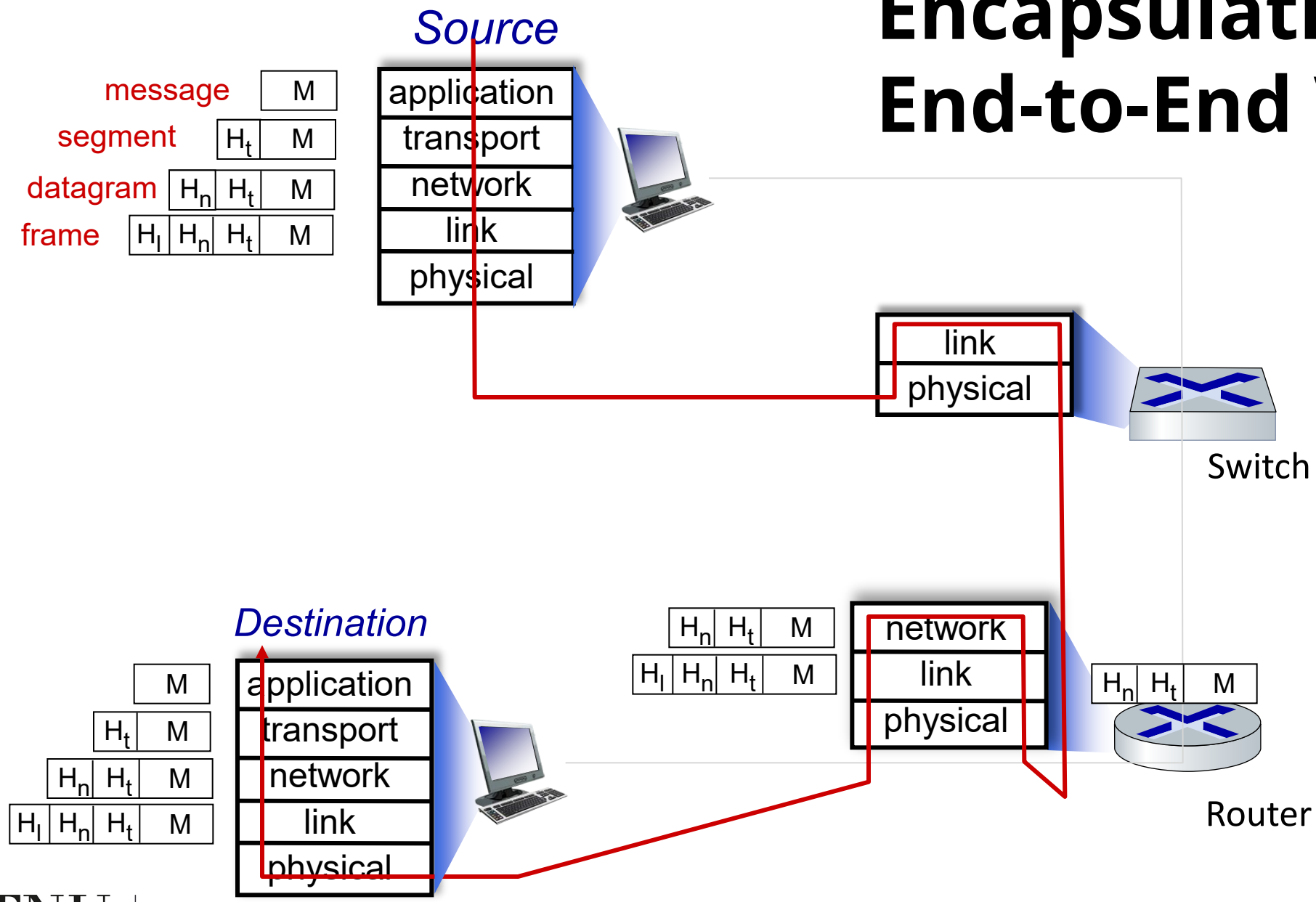


Credit: https://dribbble.com/shots/7182188-Babushka-Boi

Services, Layering, and Encapsulation



Encapsulation: an End-to-End View



Sockets and Ports

Some Network Apps

- Social networking
- Web
- Text messaging
- E-mail
- Multiplayer network games
- Streaming stored video (YouTube, Hulu, Netflix)
- P2P file sharing
- Voice over IP (e.g., Skype)
- Real-time video conferencing (e.g., Zoom)
- Internet search
- Remote login
- …

Processes Communicating

Process: program running within a host

- Within same host, two processes communicate using inter-process communication (defined by OS)
- Processes in *different* hosts communicate by exchanging messages

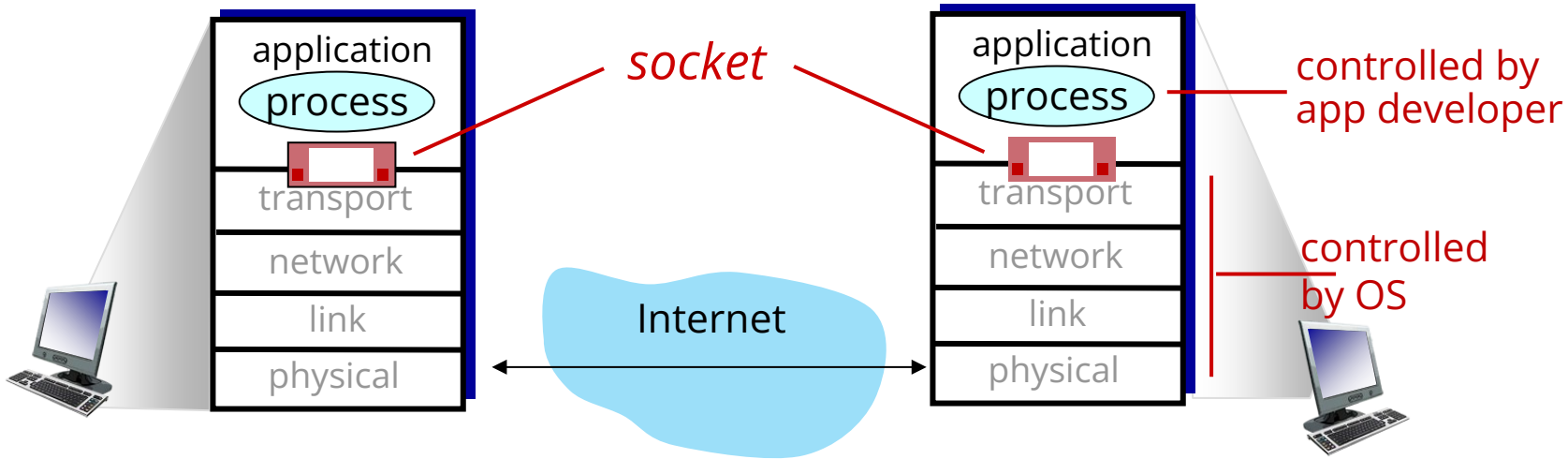
Clients, servers

Client process: process that *initiates* communication

Server process: process that *waits* to be contacted

Sockets

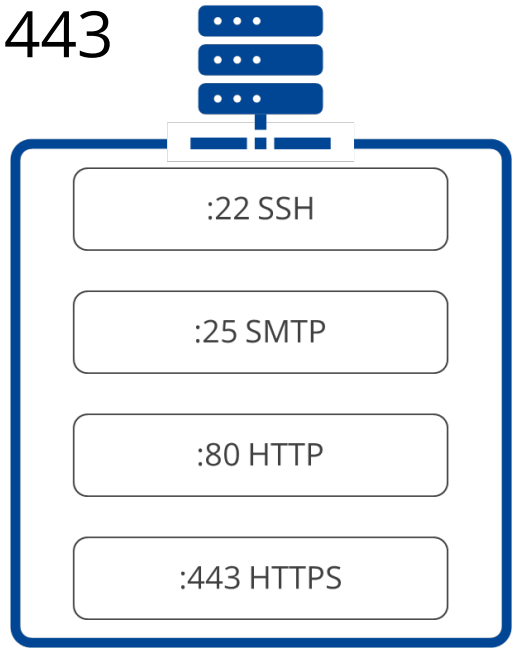
- Process sends/receives messages to/from its socket
- Socket analogous to door
  - Sending process shoves message out the door
  - Sending process relies on transport infrastructure on other side of door to deliver message to socket at receiving process
  - Two sockets involved: one on each side



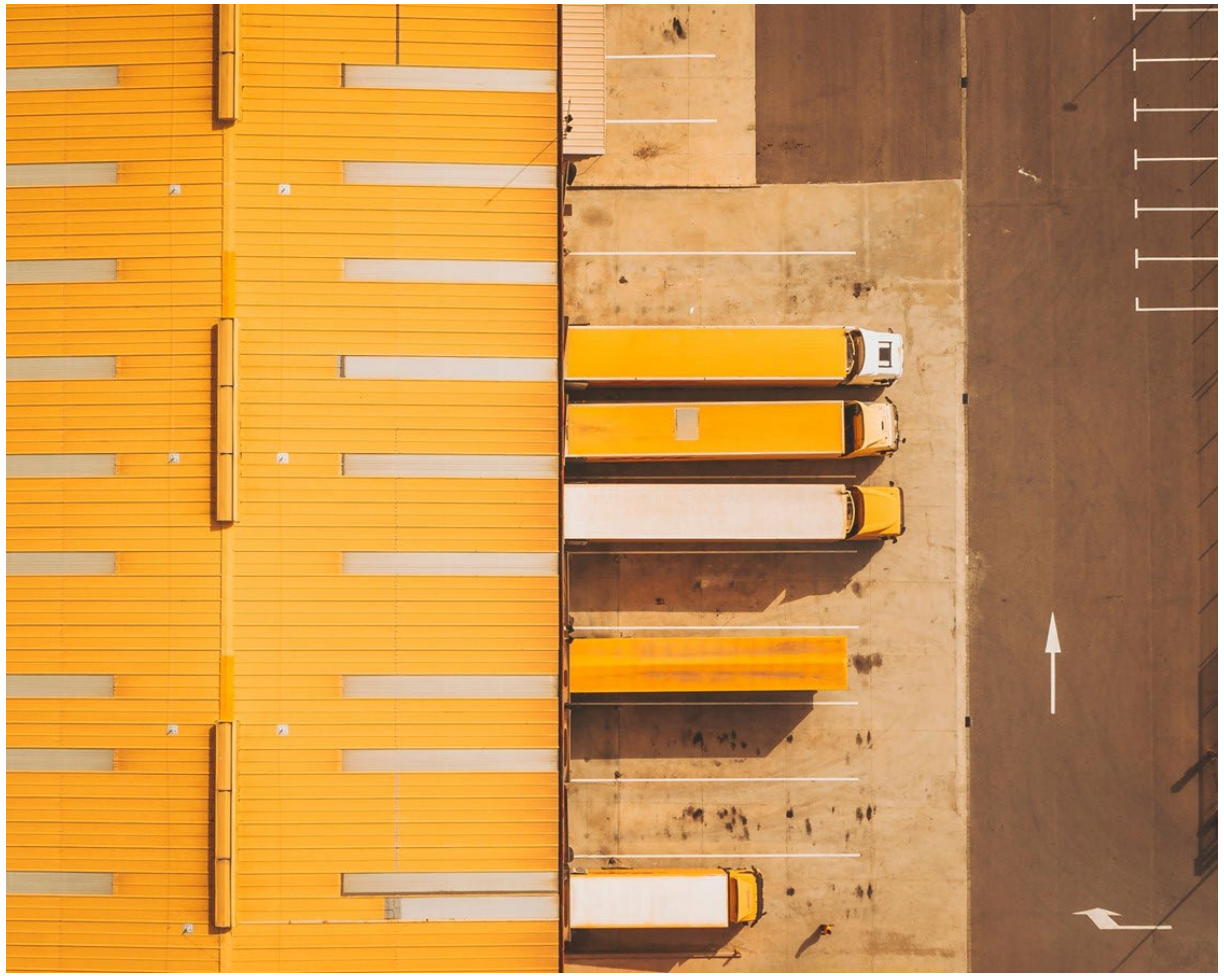
Addressing Processes

- To receive messages, process must have *identifier*
- Host device has unique 32-bit IP address
- *Q:* does IP address of host on which process runs suffice for identifying the process?
  - *A:* no, *many* processes can be running on same host

- *Identifier* includes both IP address and port numbers associated with process on host
- Example port numbers
  - HTTP(S) server: 80, 443
  - SSH: 22
  - Mail server: 25



Transport Protocols and Applications



Application-Layer Protocols Define

- Types of messages exchanged, e.g., request, response
- Message syntax
  - What fields in messages & how fields are delineated
- Message semantics
  - Meaning of information in fields
- Rules for when and how processes send & respond to messages

Open protocols

- Defined in RFCs, everyone has access to protocol definition
- Allow for interoperability
- Examples: HTTP, SMTP

Proprietary protocols:

- Examples: Skype, Zoom

What Transport Service Does an App Need?

Data integrity

- Some apps (e.g., file transfer, web transactions) require 100% reliable data transfer
- Other apps (e.g., audio) can tolerate some loss

Timing

- Some apps (e.g., Internet telephony, interactive games) require low delay to be "effective"

Throughput

- Some apps (e.g., multimedia) require minimum amount of throughput to be "effective"
- Other apps ("elastic apps") make use of whatever throughput they get

Security

- Encryption, data integrity, …

Transport Service Requirements of Common Apps

Application	Data loss	Throughput	Time-sensitive?
File transfer/download	no loss	elastic	no
E-mail	no loss	elastic	no
Web documents	no loss	elastic	no
Real-time audio/video	loss-tolerant	audio: 5Kbps-1Mbps video:10Kbps-5Mbps	yes, 10's msec
Streaming audio/video	loss-tolerant	same as above	yes, few secs
Interactive games	loss-tolerant	Kbps+	yes, 10's msec
Text messaging	no loss	elastic	yes and no

Internet Transport Protocols Services

TCP service

- *Reliable transport* between sending and receiving process
- *Flow control:* sender won't overwhelm receiver
- *Congestion control:* throttle sender when network overloaded
- *Connection-oriented:* setup required between client and server processes
- *Does not provide:* timing, minimum throughput guarantee, security

UDP service

- *Unreliable data transfer* between sending and receiving process
- *Does not provide:* reliability, flow control, congestion control, timing, throughput guarantee, security, or connection setup

Internet Applications and Transport Protocols

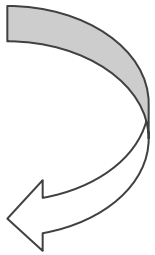
Application	App. layer protocol	Transport protocol
File transfer/download	FTP [RFC 959]	TCP
E-mail	SMTP [RFC 5321]	TCP
Web documents	HTTP [RFC 7230, 9110]	TCP
Internet telephony	SIP [RFC 3261], RTP [RFC 3550], or proprietary	TCP or UDP
Streaming audio/video	HTTP [RFC 7230], DASH	TCP
Interactive games	WOW, FPS (proprietary)	UDP or TCP


docker

Slide adapted from Jérôme Petazzoni, “Introduction to Docker and Containers”, QCON SF 2017, https://qconsf2017intro.container.training, https://www.youtube.com/playlist?list=PLBAFXs0YjviLgqTum8MkspG_8VzGl6C07

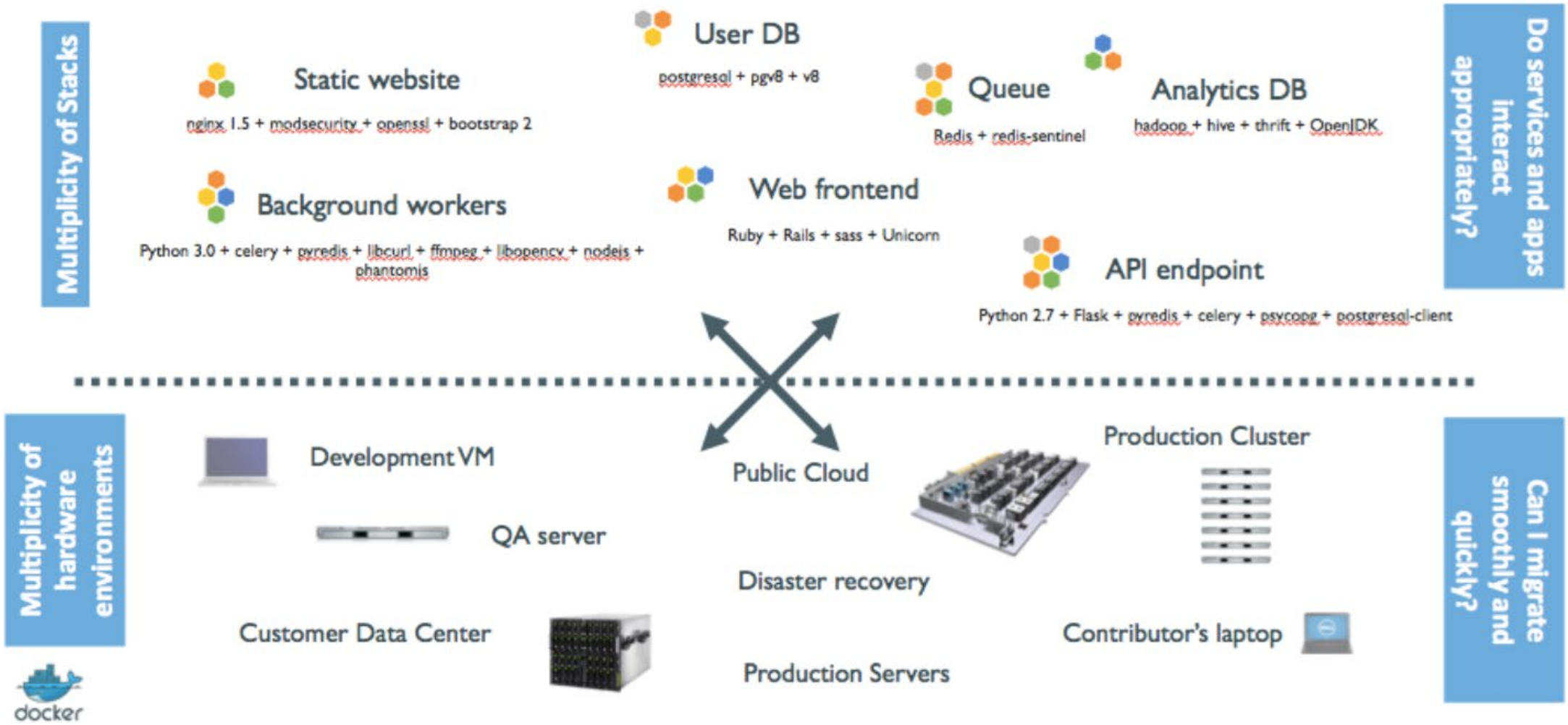
Docker – Motivation

- Software industry has changed
  - Before
    - Monolithic applications
    - Long development cycles
    - Single environment
  - Now
    - Decoupled services
    - Fast, iterative improvements
    - Multiple environments



- Many different *stacks*
  - Languages
  - Frameworks
  - Databases
- Many different targets
  - Individual dev environments
  - Pre-production, QA, ..
  - Production

The Deployment Problem



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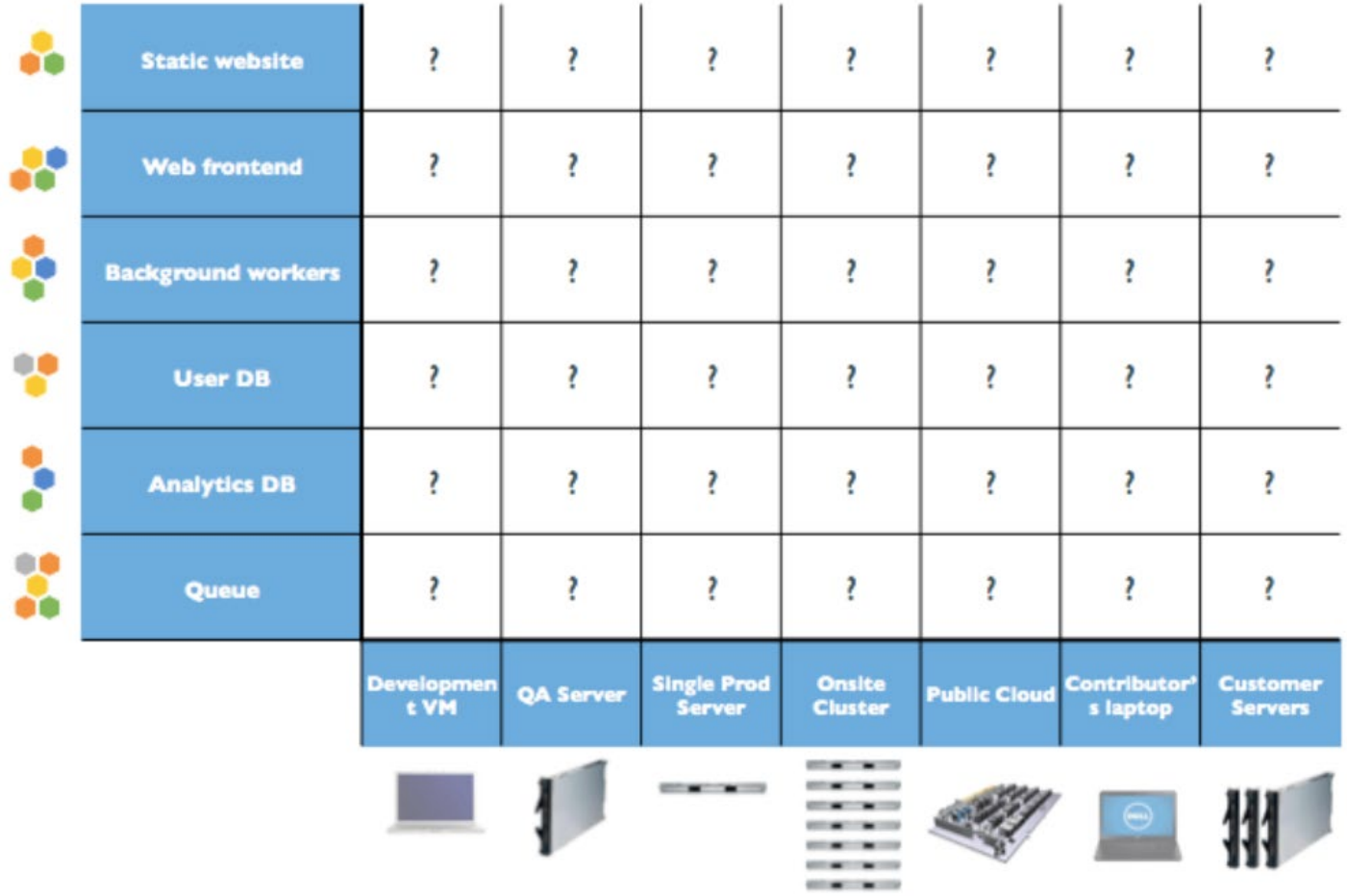
Multiplicative Complexity



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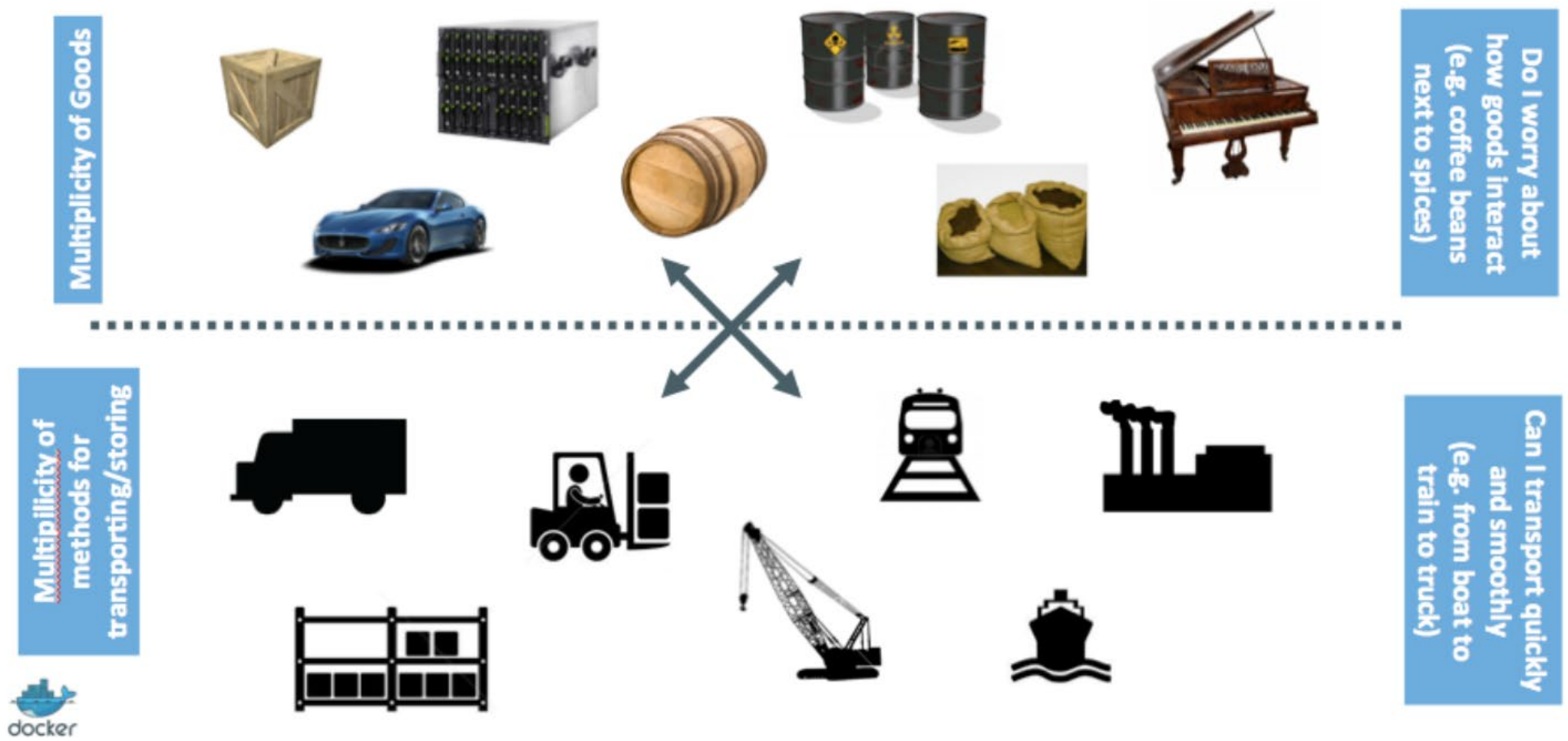
Shipping Analogy



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New Shipping Ecosystem

- 90% of all cargo now shipped in a standard container
- Order of magnitude reduction in cost and time to load and unload ships
- Massive reduction in losses due to theft or damage
- Huge reduction in freight cost as percent of final goods (from >25% to <3%)

→ massive globalization

- 5000 ships deliver 200M containers per year

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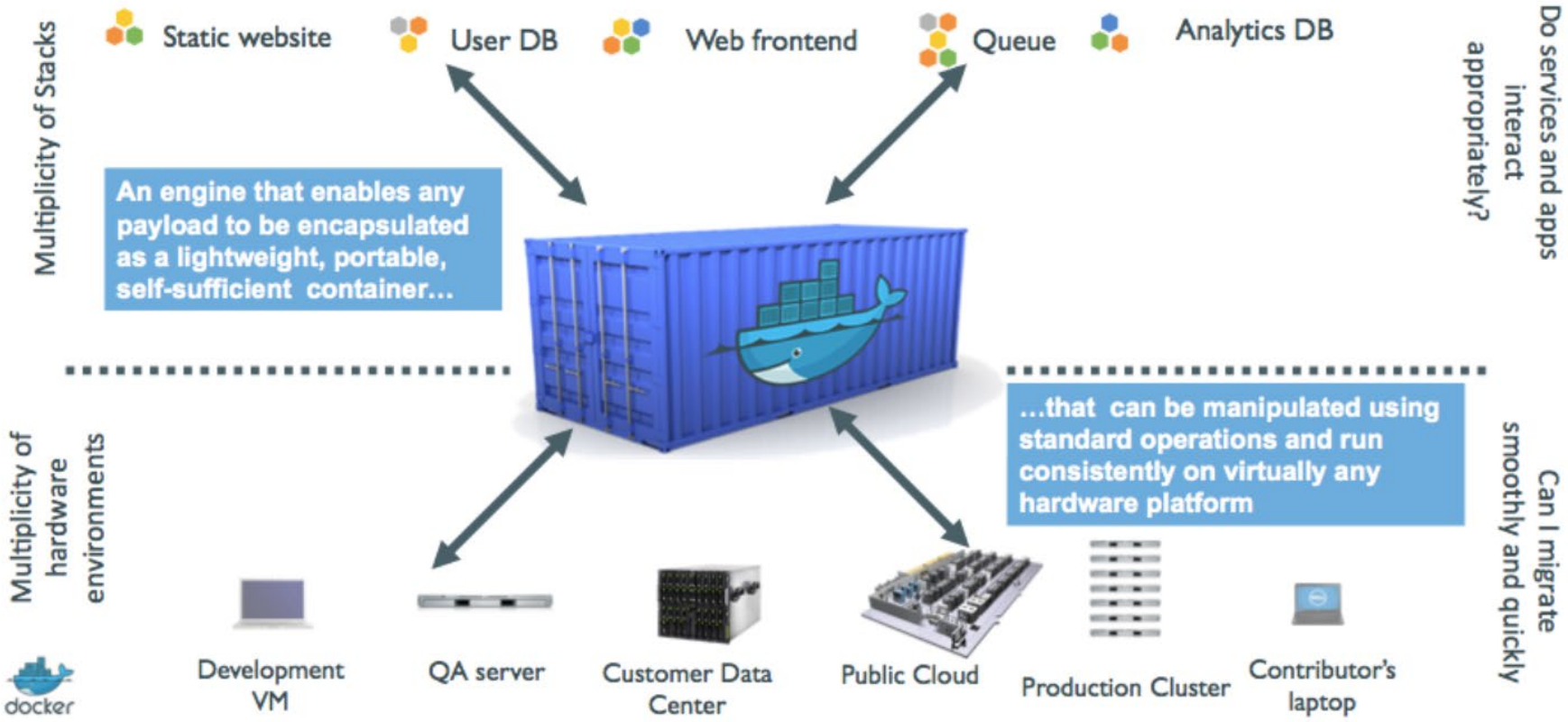
Container System for Applications



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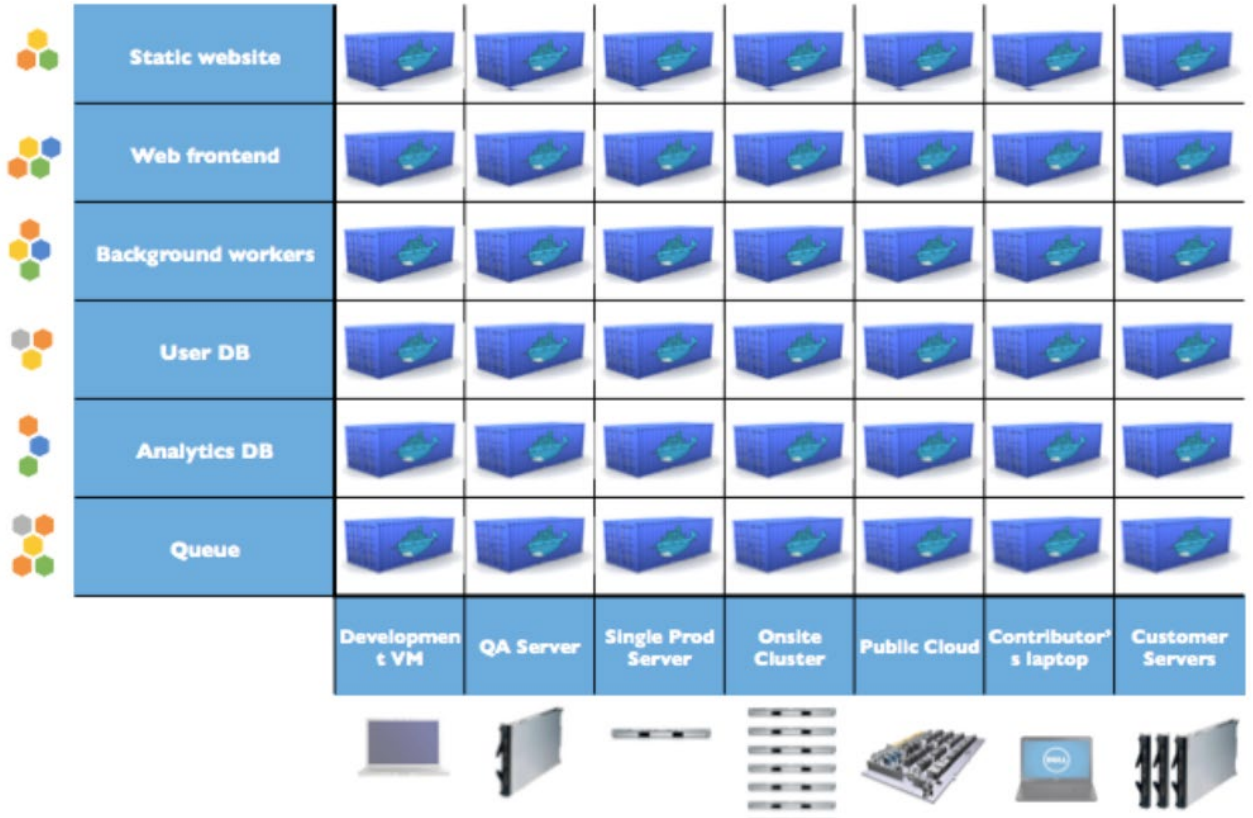
Eliminating Complexity



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Docker – Pros and Cons

+ Escape dependency / “works on my machine” issues
+ Easier onboarding using pre-made images / environments
+ Untainted tests with fresh clean state on each run
+ Standardized formats, APIs, abstractions
- Security and performance isolation can be tricky
- Additional complexity layer(s) for orchestration

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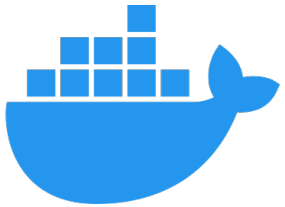
https://www.gns3.com/assets/custom/gns3/images/logo-colour.png
https://en.wikipedia.org/wiki/File:Docker_logo.svg

Lab Program Today

- Run a web server in your local GNS3 network
- Learn about
  - Hypertext Transfer Protocol (HTTP)
  - Ports, layers, and packets
- Get hands-on experience with Docker
  - Images vs containers
  - Running and attaching to containers
  - Building and running your own images

GNS3®



docker

Next Week: Networking Lab III

- Topics: routing, DNS, services
- Goals
  - Recognize the role of routing in networking
  - Use `ip route` for managing routes
  - Retrieve basic DNS information
  - Deploy basic network services
- Preparation material & BB announcement on Monday
- ! Remember the reflections after the lab