

COL788: Advanced Topics in Embedded Computing

Lecture 1 – Introduction to Embedded Systems



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August 4, 2022

Semester I
2022-2023

Agenda

- Motivation

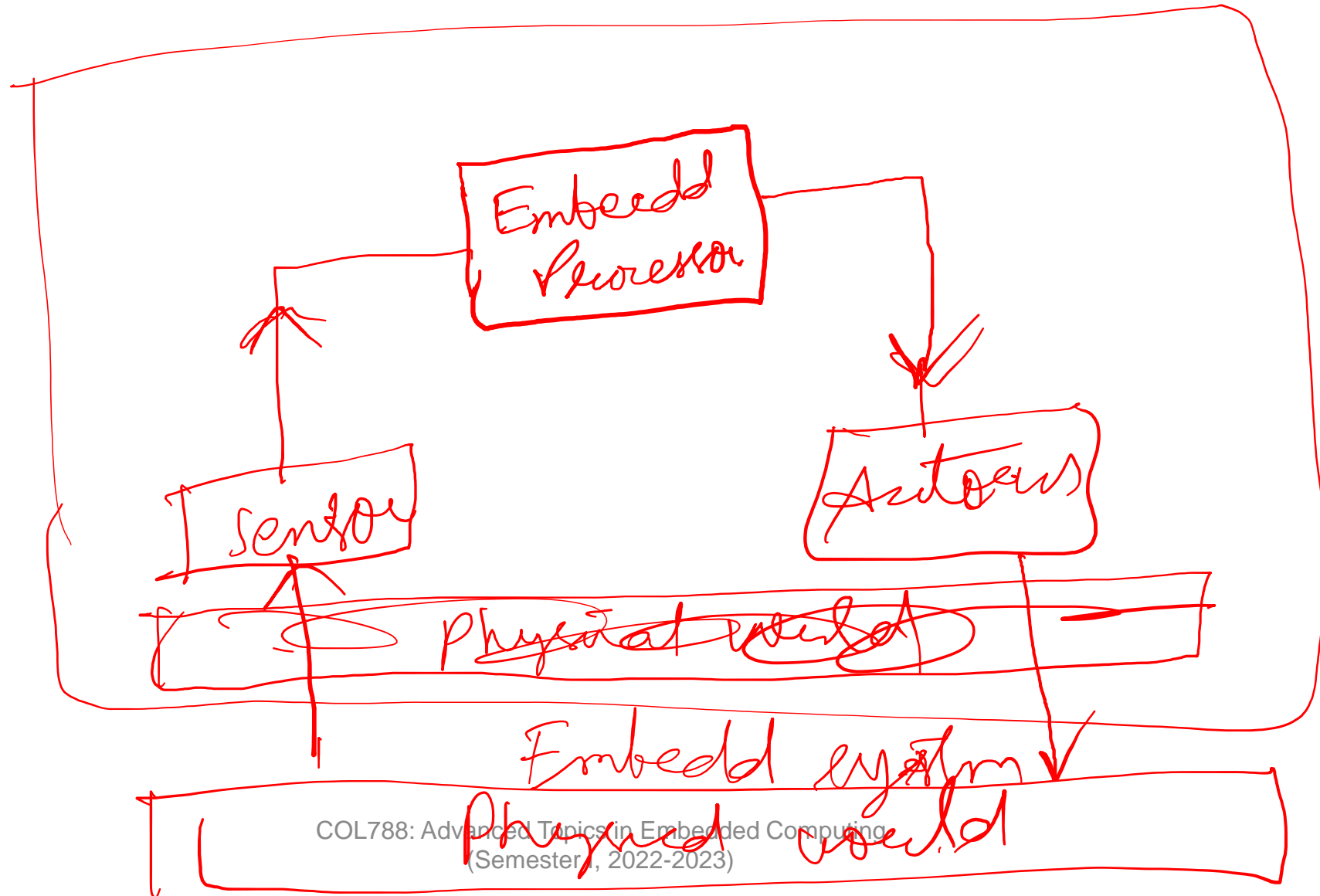
Some of the slide contents have been borrowed from those utilized by Prof. Kolin Paul.

Embedded Systems

- Ubiquitous Invisible Computers
 - Automobiles
 - Drone
 - Printers
- Features
 - Interaction with physical systems
 - Limited resources
 - Storage
 - Computation
 - Communication
- Critical
 - Boeing 737 Max accidents due to sensor-related errors ([The New York Times](#))

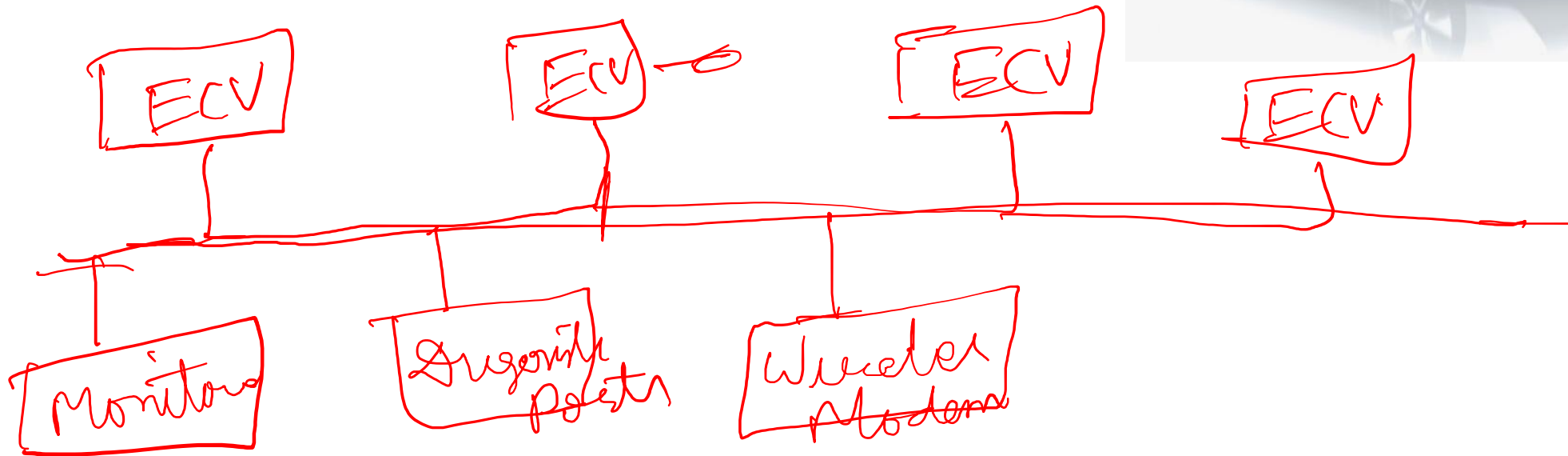


Connecting Cyber and Physical Worlds



Automotives

- Electronic control units (ECUs)
 - 100-200
- Communicate over wired protocols



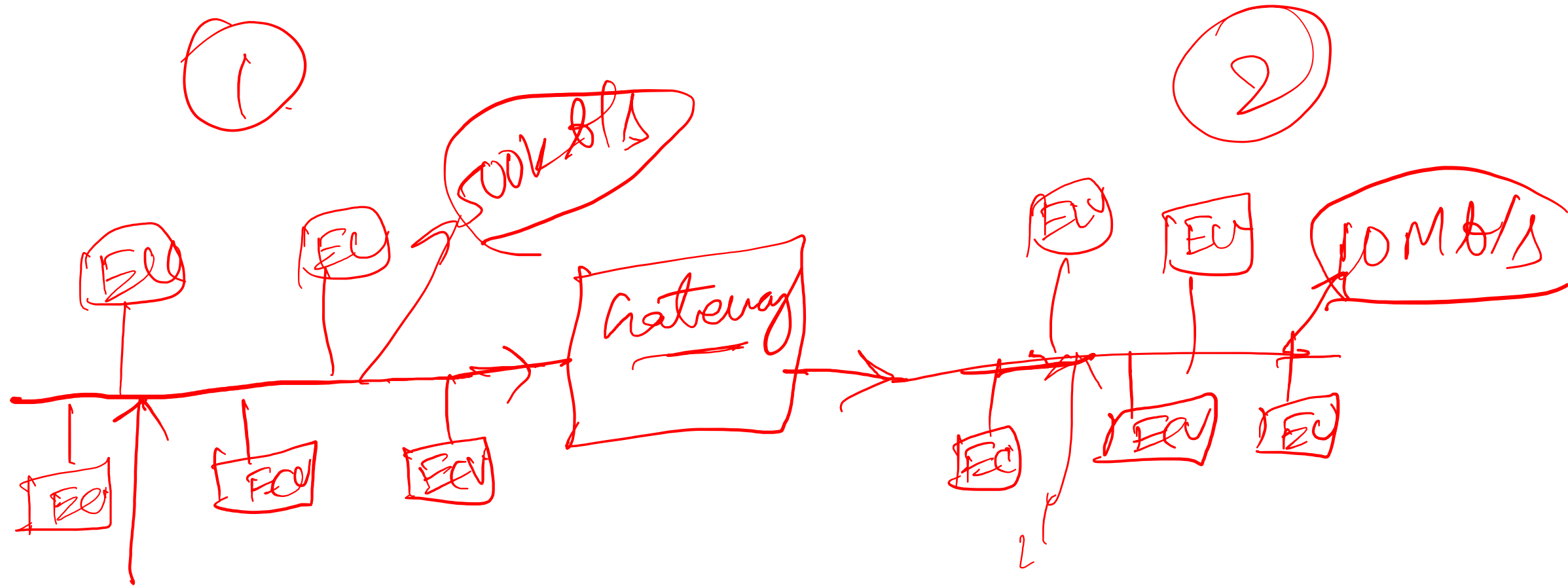
Automotive Functions

- Powertrain
 - Engine control, transmission and gear control
- Chassis
 - Antilock Braking System, Electronic Stability Program, Automatic Stability Control, Adaptive Cruise Control
- Body (comfort)
 - Air conditioning and climate control, dash board, wipers lights, doors, seats, windows, mirrors, cruise control, park distance control
- Telematics
 - Multimedia, infotainment, GPS and in-vehicle navigation systems, CD/DVD players, rear-seat entertainment
- Passive safety (emergency)
 - Rollover sensors, airbags, belt pretensioners

Typical Specifications

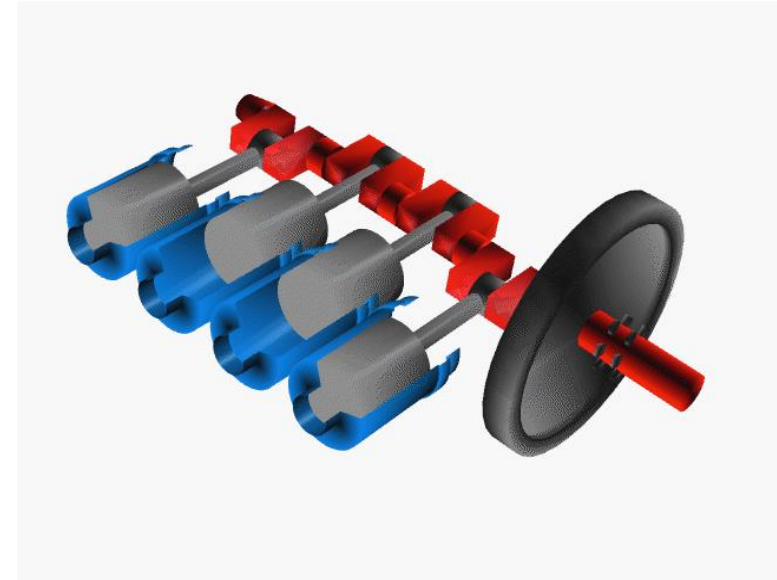
	Powertrain	Chassis	Body	Telematics	Passive safety
Program size	2 MB	4.5 MB	2.5 MB	100 MB	1.5 MB
Number of ECUs	3-6	6-10	14-30	4-12	11-12
Number of messages	36	180	300	660	20
Bus topology	Bus	Bus	Bus	Ring	star
Bandwidth	500 Kb/s	500 Kb/s	100 Kb/s	22 Mb/s	10 Mb/s
Cycle time	10 ms – 10 s	10 ms – 10 s	50 ms 2 s	20 ms 0.5 s	50 ms
Safety requirements	High	High	Low	Low	Very high

Gateways between Buses



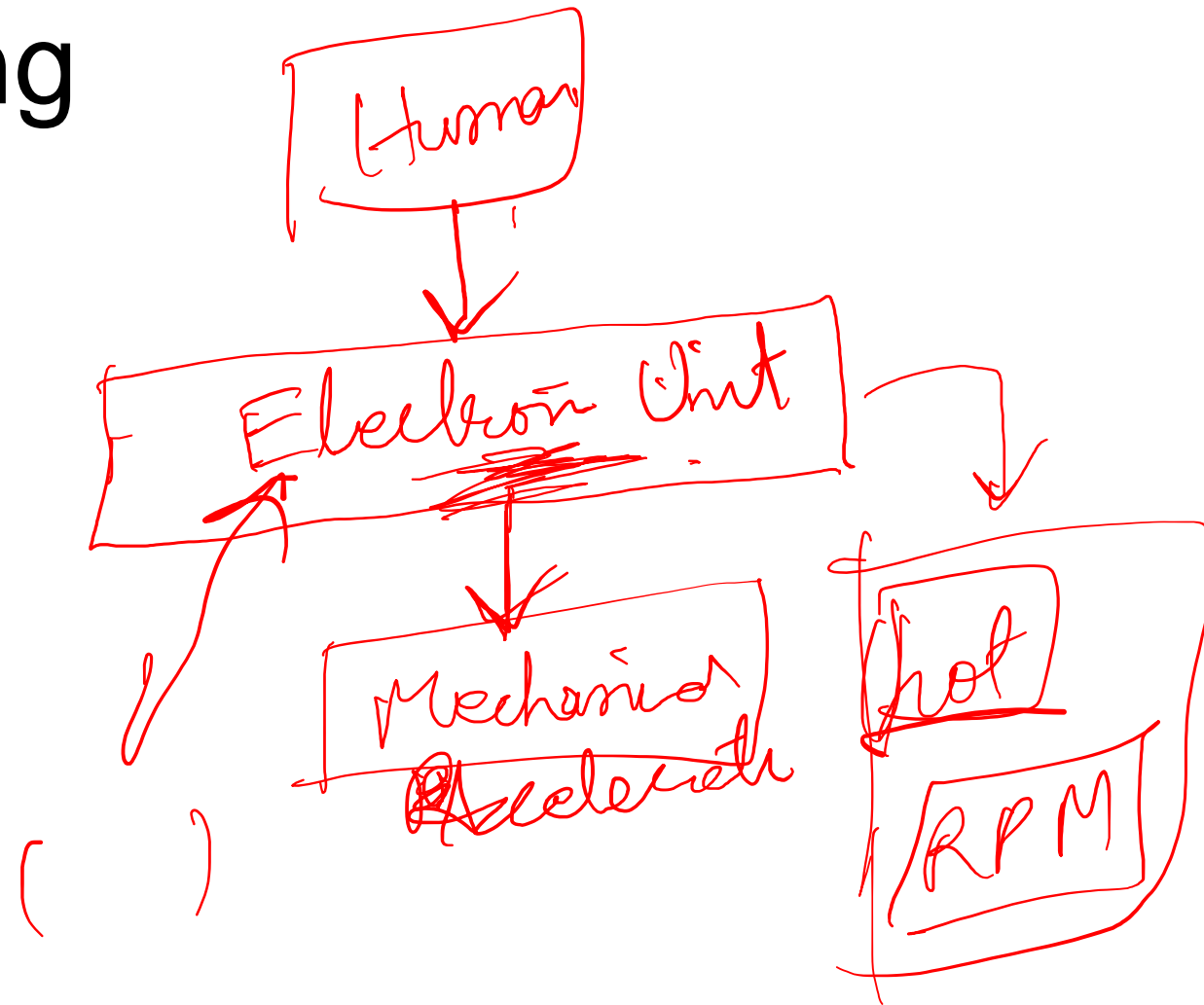
Engine Control

- Task of engine control
 - calculate amount of fuel
 - exact moment of injection
- Dependencies
 - pedal (driver)
 - load of the engine
 - temperature
- Sensors and actuators
 - position of crankshaft
 - valves
- Relevance
 - avoid mechanical damage
 - provide quality of control (e.g., fuel efficiency)



Computer Engineering

- Applications
 - Receive sensor data
 - Perform computation
 - Send actuator data
- Requirements
 - Real-time?



Capabilities of Automotive ECUs

- Computational Constraints
 - Less than 100 MHz
- Communication Constraints
 - Less than 100 bits
- Storage Constrains
 - Less than 100 MB

Experiments on Arduino Uno Board

- <https://rweather.github.io/arduinolibs/crypto.html>
- Example-1: AES-based Encryption
- Example-2: ECC-based Diffie-Hellman Key Exchange

What's Next?

- Next Lecture (August 8, 11 am – 12 pm)
 - Lecture 2