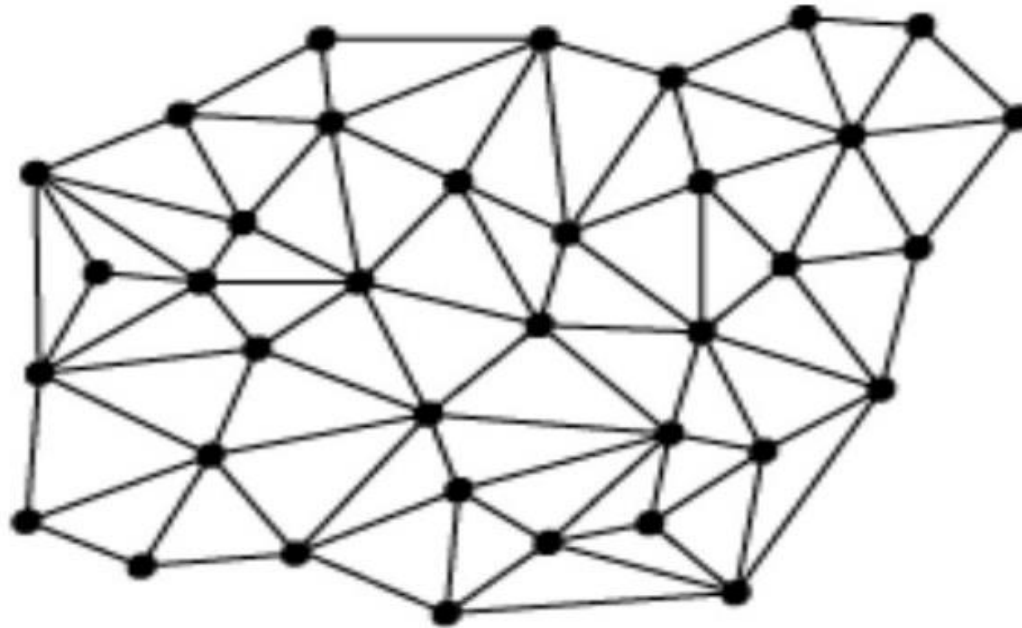


Distributed System Course

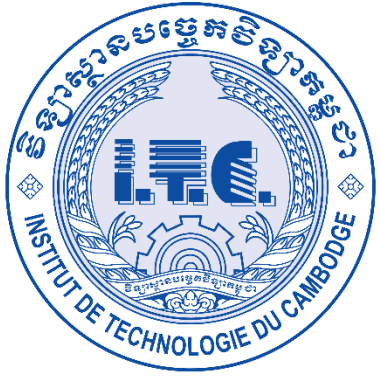
2021-22-GICI41SSD-Distributed System



Academic Year: 2021-2022 Lecturer: SOK Kimheng

Information

Course	Distributed System	48h, 12 Weeks, 4h/week (3 Groups = 96h)
General Distributed System	Week 1	Information, Self-Study Skill, Introduction
	Week 2	Distributed Communication (TCP/IP, Socket, RPC, REST, gRPC, OMQ)
	Week 3	Clock, Timestamp
	Week 4	Fault Tolerance (Two general problem, Byzantine General Problem)
	Week 5	Consensus Algorithm (Paxos, ZooKeeper, Raft)
	Week 6	Quiz
Blockchain	Week 7	Basic Cryptography
	Week 8	Blockchain and Bitcoin (Proof of Work)
	Week 9	Ethereum and Smart Contract (Proof of Stake)
	Week 10	Hyperledger and Self-Sovereign Identity
	Week 11	Security
	Week 12	Final Exam



Distributed System Course

2021-22-GICI41SSD-Distributed System

Week4:

Fault Tolerance

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Agenda

- 1 Definition
- 2 Two generals problem
- 3 Byzantine general problem

Fault Tolerance

Definition

- Fault: The cause of malfunction or error in the system.
- Failure: The effect due to the fault (problem) either by hardware or operating system software that causes the system to end abnormally.
- Fail Safe: In the event of the failure, the system choose to fail in a manageable manner.

Fault Tolerance

Type of fault

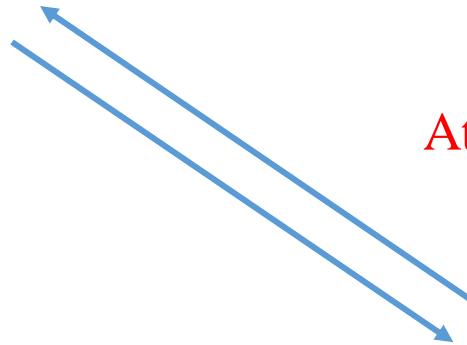
- Memory and CPU consumption
- Cable disconnect
- Network timeout
- Hardware failure
- Software error or bugs

Solution

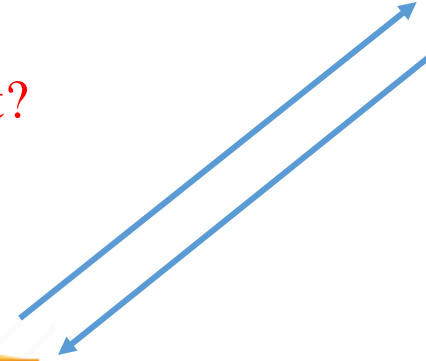
- Replication | Redundancy

Fault Tolerance

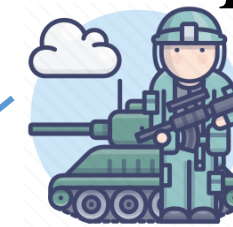
Two Generals problem



Attack or Retreat?



$n = 2$



Fault Tolerance

Two Generals problem



Attack

OK, I Attack too

OK, We all Attack



$n = 2$



Best case scenario

Fault Tolerance

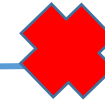
Two Generals problem



Attack

OK, I Attack too

OK, We all Attack



$n = 2$



Message lost

Fault Tolerance

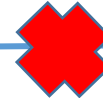
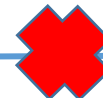
Two Generals problem



Attack

OK, I Attack too

OK, We all Attack



$n = 2$

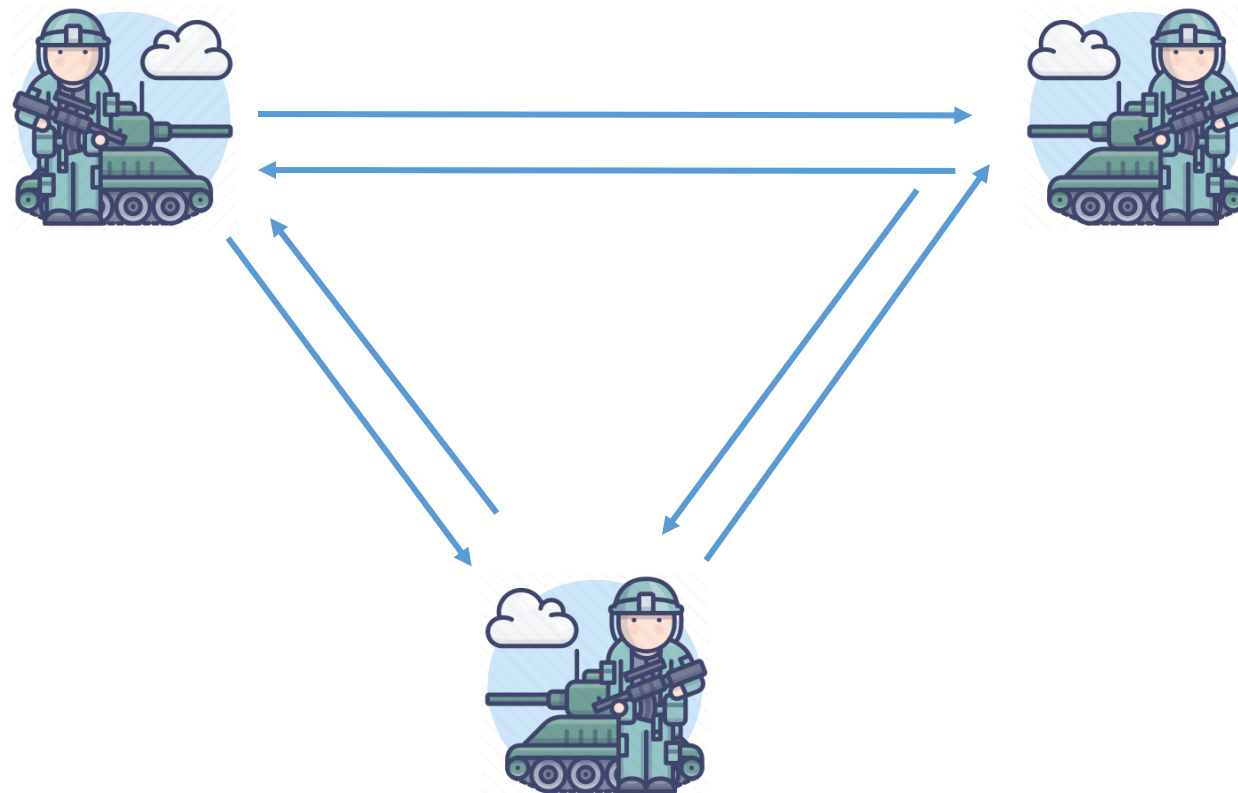


Message lost

Fault Tolerance

Byzantine Generals problem

$n = 3$






Total number of generals are 3 or more

Fault Tolerance

Byzantine Generals problem

$$n = 3$$
$$f = 1$$

	-----	Attack	Retreat	-----
	Attack	Attack	Retreat	Attack
	Retreat	Attack	Retreat	Retreat

3 generals with 1 general traitor / malicious / faulty

Fault Tolerance

How many n do we need to tolerate f faulty?

- Up to f generals might behave maliciously
- Honest generals don't know who the malicious ones are
- The malicious generals may collude
- Honest generals must agree on plan

Theorem:

- Need $3f+1$ to tolerate f malicious generals
 - Less than $1/3$ are malicious

Fault Tolerance

Key take away

- Nodes need to communicate with each other
- Majority ideas is the global decision
- Voting or Election is needed for any decision to be approved
- Communication come with cost, so sometime centralized approach is used (*Leader-based approach*)
- There are many alternative and complement approaches for decision making. (*Next chapter Consensus Algorithm*)