Computer Systems

Gnkgo, Computer Science, Bsc 5. Semester

Lecture 1

- Parallelism / Concurrency
- Failures / Fault-tolerance
  - Availability
  - Reliability
- Geography

Problems with Distributed Systems

- State replication!
  - C1, C2, C3, C4, ...
- 3 exactly once
- 1 correct order
- 2 exactly once

Lecture 2

Consensus (Model)

Cannot be solved

- n nodes ($n \geq 2$), input value $v_i = \{0, 1\}$
- $f < n$ faulty (crash), $n - f$ correct
  - message passing
  - reliable
  - async
- $f \geq 1$

Consensus (Problem)

- agreement: all correct nodes $\rightarrow$ some value
- termination: finite messages
- validity: decision is input of some node

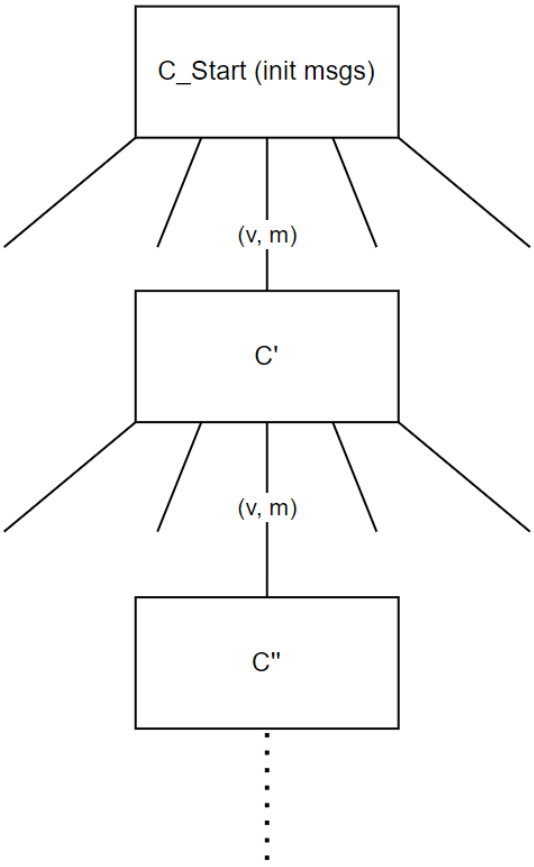
Async

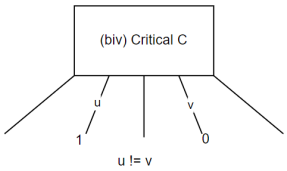
- **init**: send
- **event**: receive msg $(v, m) \rightarrow$ send

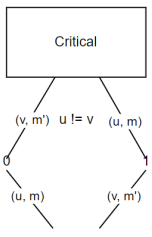
Configuration C

- = state of all nodes + msgs in transit
- C bivalent: both still possible
- C univalent: 0-valent, 1-valent
- C critical: bivalent, but all children univalent

Example: C_{start} (init msgs)







Lecture 3

- Consensus = byzantine agreement

- f crash $\rightarrow$ "byzantine", $n - f$ correct
- agreement
- termination
- validity

Validity

- any - input?
- correct - input $\rightarrow (f + 1)$-validity
- median - validity (range of inputs)

Example: $f = 1$

async: event
sync:

time	activity
1	send
2	receive
3	compute
1	send
...	...

Exercise Lecture 2

Challenges

- Messages can get lost
- Nodes may crash
- Messages can have varying delays

First Approaches

Server sends acknowledgment message.

Eventual Consistency & Bitcoins

Paxos - Main Ideas

1. Tickets ("weak lock", expiration)
2. Require majority
3. Servers inform clients about their stored command

Lecture 4

Quorum

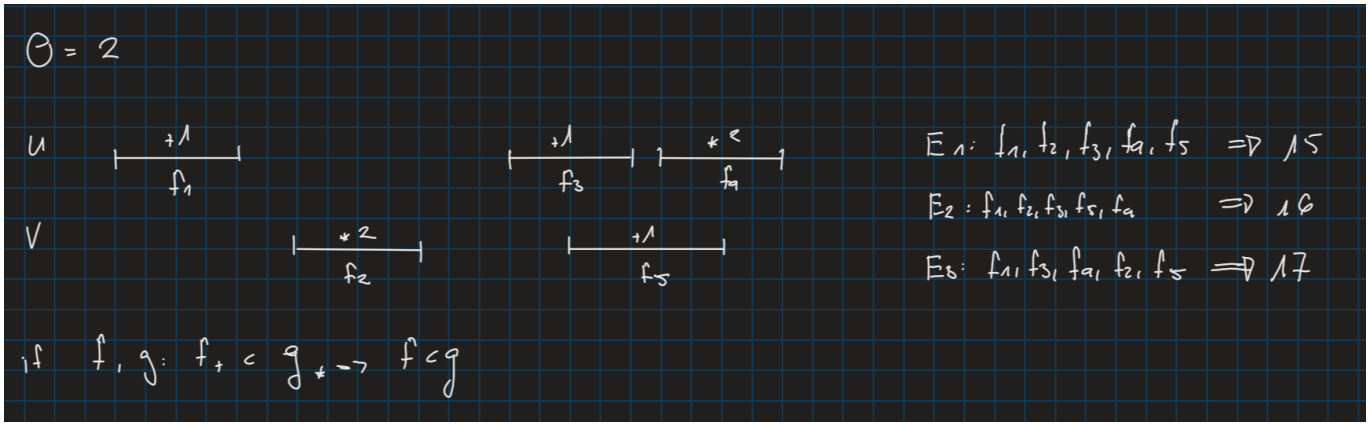
Majority QS:

$$S = \{X \subseteq \{v_1 ... v_m\} || x| > \frac{m}{n}\}$$

Lecture 6

Sequential Execution S

$$\forall f, g \in S: \text{ either } f < g \text{ or } g < f$$



Logical Clock

$$C_u : \text{operations} \rightarrow \text{"points in time"}$$

Lampot Clock

$$c_u := 0$$

upon local op:

$$C_: = c_u + 1$$

Lecture 7

Time

Second → International Atomic Time (TAI) → Coordinated Universal Time (UTC) → Time

Quiz Questions

- Does Paxos solve Consensus? No, termination is not guaranteed.