Distributed Computing
Environments
Distributed computing environment

• consists of entities

• entities communicate with each other

• the goal is to find a solution to a common problem
Entities

• entity: a computational unit of a distributed computing environment
  – e.g. a computer, a processor, a process, etc.

• operations:
  – local storage and processing
  – transmission of messages
  – (re)setting of the alarm clock
  – changing the value of the status registers
External events

• an entity is reactive (i.e. it only responds to external stimuli)

• external events:
  – (1) arrival of a message
  – (2) ringing of the alarm clock
  – (3) spontaneous impulse

• events (1) and (2) originate within the system

• event (3) originates outside the system
Actions and behavior

• entity reacts to an event by an action

• an action is a finite, indivisible (atomic) and terminating sequence of operations

• an action is determined by the behavior and the current status

• behavior is a complete and unambiguous set of rules

• a rule is in the form of $status \times event \rightarrow action$

• current status is determined by the status register
Communication

- entities communicate by transmitting and receiving messages
- a message is a finite sequence of bits
- an entity can only communicate with its neighbors
  - it can send messages to its out-neighbors
  - it can receive messages from its in-neighbors
  - the set of in-neighbors is not necessarily equal to the set of out-neighbors
Axioms

• axiom 1: finite communication delays
  – in the absence of failures, communications delays are finite

• axiom 2: local orientation
  – an entity can distinguish among its in- and out-neighbors
Restrictions

- a restriction is an additional property of the system
- common restrictions:
  - message ordering
  - reciprocal communication
  - bidirectional links
  - edge/entity failure detection
  - guaranteed delivery
  - partial/total reliability
  - connectivity
  - bounded communication delays
  - synchronized clocks
Cost and complexity

- measuring efficiency of an algorithm in different systems needs some abstract and general cost measures

- amount of communication activities
  - the number of message transmissions
  - the number of bits transmitted

- time
  - total execution delay: the delay between start and end of a computation in the system
  - cannot be accurately measured (without assumptions, delays are unpredictable)
Levels of knowledge

- **local knowledge:** $p \in \text{LK}_t[x]$
  - local information of an entity (contents of its memory)

- **implicit knowledge:** $p \in \text{IK}_t[W]$ iff $\exists x \in W (p \in \text{LK}_t[x])$
  - at least one entity $x$ knows $p$

- **explicit knowledge:** $p \in \text{EK}_t[W]$ iff $\forall x \in W (p \in \text{LK}_t[x])$
  - every entity in the group $W$ knows $p$

- **common knowledge:** $p \in \text{CK}_t[W]$ iff $\land_{1 \leq i \leq \infty} P_i$, where $P_1 = [p \in \text{EK}_t[W]]$ and $P_{i+1} = [P_i \in \text{EK}_t[W]]$
  - every entity knows $p$, and every entity knows that every entity knows $p$, and so on
Example of common knowledge

There’s a room with $k$ people who have blue eyes. Rest of the people have green eyes. A person doesn’t know the color of his/her eyes. People cannot communicate with each other, nor are there any mirrors in the room. If a person finds out to have blue eyes, he/she must leave the room in the next morning. An outsider visits the room and announces, that there’s at least one blue-eyed people in the room. Can a person find out the color of his/her eyes and is it possible for all blue-eyed people to exit the room together?
Summary

• the computational unit of a distributed environment is called an entity

• entities can do local processing and communicate with other entities

• external events: arrival of a message, alarm clock ring and spontaneous impulse

• there can be assumptions (restrictions) about the environment

• communication activity and execution delay are measures of efficiency of an algorithm

• sometimes it is necessary for entities to reach a consensus
Thank you!
Questions?