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: $p \in \mathrm{LK}_t[x]$
  - local information of an entity (contents of its memory)
- implicit knowledge: $p \in \mathrm{IK}_t[W]$ iff $\exists x \in \mathrm{W}\ (p \in \mathrm{LK}_t[x])$
  - at least one entity x knows p
- explicit knowledge: $p \in \mathrm{EK}_t[W]$ iff $\forall x \in W\ (p \in \mathrm{LK}_t[x])$
  - every entity in the group W knows p
- common knowledge: $p \in \mathrm{CK}_t[W]$ iff $\wedge_{1 \leq i \leq \infty} P_i$, where $P_1 = [p \in \mathrm{EK}_t[W]]$ and $P_{i+1} = [P_i \in \mathrm{EK}_t[W]]$
  - every entity knows p, and every entity knows that every entity knows p, and every entity knows that 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
- entites 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?