Non-determinism

Definition

A property of a computation which may have more than one result.

Non-determinism by design

A property of the computation environment which may lead to different sequences of concurrent stimuli.

Non-determinism by interaction

A property of the computation which may have more than one result.

Non-determinism by design

Select banner 1

Selective Synchronization

Message-based selective synchronization in Ada

(*readfds*), *exceptfds*, *sigmask*, struct timespec, sigset_t

```
select

|block, all cases need to be covered and overlapping conditions need to lead to the same result
|The boolean expressions are local expressions, i.e. if none of them evaluates to true
|The programmer does not need to handle any of the details of a concurrent implementation
|The programmer needs to understand the current language support: Ada, X10, Chapel, Fortress, Haskell, OCaml, …

Semaphore

The boolean expressions are local expressions, i.e. if none of them evaluates to true

```
Selective Synchronization

Message-based selective synchronization in Ada

Forms of selective calling:

- entry_call_statement
- entry_call_statement
- entry_call_statement
- entry_call_statement

Conditional entry-calls

conditional_entry_call ::= select_statement

Example:

Light_Monitor.Wait_for_Light; Lux := True;

Timed entry-calls

timed_entry_call ::= delay

Example:

Light_Monitor.Wait_for_Light; Lux := False;

Correctness of non-deterministic programs

Partial correctness:
P(S) & P(I) => Q(S) & Q(I)

Correctness predicates need to hold true (irrespective of the actual sequence of interaction points)

Liveness properties:
P(L) & P(I) => Q(L) & Q(I)

Correctness predicates need to be satisfied for all possible sequences of interaction points

Sources of Non-determinism

- Operating systems / runtime environments:
  - Schedulers are often non-deterministic.
  - System load will have an influence on concurrent execution.
  - Timers drift and clocks have granularities.

- Networks & communication systems:
  - Traffic will arrive in an unpredictable way (non-deterministic).

- Computing hardware:
  - Hardware and software systems connected to the physical world

Summary

- Non-determinism by design:
  - Selective synchronization
  - Conditional entry-calls
  - Timed entry-calls

- Non-determinism by interaction:
  - Selective synchronizations
  - Conditional entry-calls
  - Timed entry-calls

- Correctness of non-deterministic programs:
  - Sources of non-determinism
  - Predicates & invariants