Cockrell School of Engineering

Verifying Distributed Algorithms
in Promela

Eric Crosson
Nhan Do
Stormy Mauldin
Daniel Officewala

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Outline

Introducing Promela

Dining Philosophers

Token Ring

Lamport’s

Szymanski’s

Questions

What are Spin and Promela?

Spin is a multi-threaded software verification tool that supports the high-level language Promela to specify models of systems.

- Promela allows the user to create parallel programs that define processes, message channels, and variables.
- From the promela program, Spin can then verify various system correctness properties as well as user-defined properties

Dining Philosophers

Most Philosophers

- Want to eat:
  - Get left fork (or wait)
  - Get right fork (or wait)
- After eating:
  - Release both forks
  - Contemplate life until hungry

One "Special" Philosopher

- Want to eat:
  - Get left fork (or wait)
  - Get right fork (if fail, release *both* forks)
- After eating:
  - Release both forks
  - Contemplate life until hungry

Dining Philosopher Analysis

- **Mutually Exclusive**
  - A philospher must acquire both shared forks before eating
- **Deadlock**
  - The one special philosopher will always surrender both forks, allowing someone else to start eating.
- **Starvation**
  - The special philosopher always surrenders forks in case of conflict. May never get a change to eat.

Figure: Hungry, hungry philosophers

Token Ring Algorithm

- Simple and easily scalable
  - Pass token around ring of processes
  - Only processes with token can enter CS
  - No Starvation

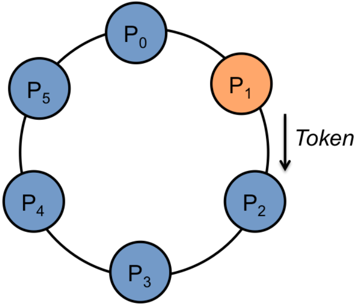


Figure: Token Ring Algorithm

Token Ring Implementation

```
#ifndef N
#define N 10
#endif

#ifndef size
#define size 10
#endif

byte state[N];
bit _Permission[N];
bit _Executing[N];

byte in_cs;
byte token;

init {
  atomic {
    byte i = 0;
        token = 0;
```

```
    do
    :: i < N –> run P(i); i++;
    :: else  –> break;
    od;
  }
}


proctype P(byte id) {
NonCritical:
  _Permission[id] = true;
  printf("Token value: %d", token);

Wait:
  _Executing[id] = true;
  if
  :: id != token –> _Permission[id] = false; goto Wait;
  :: id == token
  fi;
```

```
  if
  :: _Permission[id] == false –> goto
  :: atomic { _Permission[id] == true
  fi;
Critical:
        atomic { in_cs––; }
       printf("Process %d has entere
       _Permission[id] = false;
       _Executing[id] = false;
       if
    :: token < N –> token = ((token
       :: atomic{token > (N–1) –> to
}
    fi;
       goto NonCritical;
}
```

Lamport's

An equation block

$$\vec{F} = m\vec{a}$$

- Second instance of citations use short citation hyperlinked to original.

Szymanski's Algorithm

- Extension of Lamport's
  - satisfies linear wait
  - three booleans per process
- Extension of Lamport's

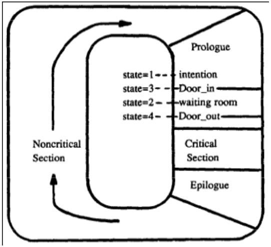
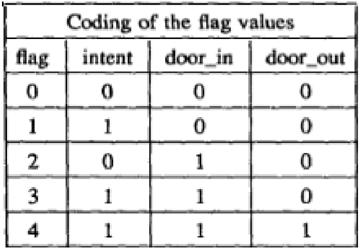


Figure: Szymanski's Algorithm



Coding of the flag values			
flag	intent	door_in	door_out
0	0	0	0
1	1	0	0
2	0	1	0
3	1	1	0
4	1	1	1

Figure: State-tracking booleans

Szymanski’s Implementation

```
start:
    /* 1. SEKCJA LOKALNA */

    local_section();

    /* 2. PROLOG */
    intent[i] = true;

started_protocol:
    skip;

    /* 3. Others are trying to
     * enter waiting room? */
    (count(1,1,0) +
      count(1,1,1) == 0);

    /* 4. Enter waiting room */
    door_in[i] = true;
```

```
anteroom_check:
    if
      :: (count(1,0,0) +
            count(1,0,1) > 0) ->
        {
            /* State 2  */
            intent[i] = false;

        in_anteroom:
            ((count(0,0,1) +
              count(0,1,1) +
              count(1,0,1) +
              count(1,1,1) > 0)
            );

            /* State 3 */
            intent[i] = true;
        }
      :: else
    fi;
```

```
    /* . Proceed into CS when
     * it is your turn */
    door_out[i] = true;

    wait_forall(k, i + 1, N,
      (!door_in[k] || door_out[k]));

    wait_forall(k, 0, i,
      (!door_in[k]));

critical_section:
    /* . SEKCJA KRYTYCZNA */

    critical_section();

    /* . EPILOG */
    door_out[i] = false;
    door_in[i] = false;
    intent[i] = false;
```

Szymanski’s Analysis

Questions

- English mothafucka, do you speak it?