1 Formal Semantics

1.1 Abstract Syntax

- Simple rules

$\langle p \rangle$ ::= mem(varid)	(memory access to '`varid`')
| await(evtid)	(await event '`evtid`')
| emit(evtid)	(emit event '`evtid`')
| nop	(no operation)

- Compound expressions

$\langle p \rangle$ ::= if mem(varid) then p else p	(conditional)
| p ; p	(sequence)
| loop p	(loop)
| loop p ; break ; p	(loop with break)
| p AND p	(par/and)
| p OR p	(par/or)

- Semantic rules

$\langle p \rangle$ ::= awaiting(evtid, n)	(awaiting event '`evtid`' since sequence number '`n`')
| emitting(n)	(emitting on stack level '`n`')
| p @ loop p	(unwinded loop)
| p • loop p	(unwinded loop within compositions)
| fin p	(finalization)

1.2 Operational Semantics

Relation-inner

$$< S, p > \xrightarrow{n} < S', p' >$$

where:

$$S, S' \in evtid \qquad \text{(sequence of event identifiers)}$$

$$p, p' \in P \qquad \text{(programs following the abstract syntax)}$$

$$n \in \mathbb{N} \qquad \text{(unique identifier for the reaction chain)}$$

Rules:

$$\langle S, mem(id) \rangle \xrightarrow{n} \langle S, nop \rangle \qquad \text{(mem)}$$

$$\langle S, await(id) \rangle \xrightarrow{n} \langle S, awaiting(id, n+1) \rangle \qquad \text{(await)}$$

$$\langle id : S, awaiting(id, m) \rangle \xrightarrow{n} \langle id : S, nop \rangle, M < n \qquad \text{(awake)}$$

$$\langle S, emit(id)\rangle \xrightarrow{n} \langle id : S, emitting(|S|)\rangle \tag{emit}$$

$$\langle S, emitting(|S|)\rangle \xrightarrow{n} \langle S, nop)\rangle \tag{pop}$$

Compound expressions:

$$\frac{mem(varid, n) \neq 0}{\langle S, \text{if mem(varid) then p else q}\rangle \xrightarrow{n} \langle S, p\rangle} \tag{if-true}$$

$$\frac{val(varid, n) = 0}{\langle S, \text{if mem(varid) then p else q}\rangle \xrightarrow{n} \langle S, q\rangle} \tag{if-false}$$

$$\frac{\langle S, p\rangle \xrightarrow{n} \langle S', p'\rangle}{\langle S, (p; q)\rangle \xrightarrow{n} \langle S', (p'; q)\rangle} \tag{seq-adv}$$

$$\langle S, (nop; q)\rangle \xrightarrow{n} \langle S, q\rangle \tag{seq-nop}$$

$$\langle S, (loop\ p)\rangle \xrightarrow{n} \langle S, (p \mathbin{@} loop\ p)\rangle \tag{loop-expd}$$

$$\frac{\langle S, p\rangle \xrightarrow{n} \langle S', p'\rangle}{\langle S, (p \mathbin{@} loop\ q)\rangle \xrightarrow{n} \langle S', (p' \mathbin{@} loop\ q)\rangle} \tag{loop-adv}$$

$$\langle S, (nop \mathbin{@} loop\ p)\rangle \xrightarrow{n} \langle S, loop\ p\rangle \tag{loop-nop}$$

$$\langle S, (break;\ p\ \ @\ loop\ p)\rangle \xrightarrow{n} \langle S, nop\rangle \tag{loop-break}$$

$$\frac{\langle S, p\rangle \xrightarrow{n} \langle S', p'\rangle}{\langle S, (p\ AND\ q)\rangle \xrightarrow{n} \langle S', (p'\ AND\ q)\rangle} \tag{and-adv1}$$

$$\frac{isBlocked(n, S, p) \qquad \langle S, q\rangle \xrightarrow{n} \langle S', q'\rangle}{\langle S, (p\ AND\ q)\rangle \xrightarrow{n} \langle S', (p\ AND\ q'\rangle} \tag{and-adv2}$$

$$\langle S, (loop\ p\ AND\ q)\rangle \xrightarrow{n} \langle S, (p\ \bullet\ loop\ p\ AND\ q)\rangle \tag{and-adv-loop1}$$

$$\frac{isBlocked(n, S, p)}{\langle S, (p\ AND\ loop\ q)\rangle \xrightarrow{n} \langle S, (p\ AND\ q\ \bullet\ loop\ q)\rangle} \tag{and-adv-loop2}$$

$$\langle S, (break;\ p\ \bullet\ loop\ p\ AND\ q)\rangle \xrightarrow{n} \langle S, (clear(q); nop)\rangle \tag{and-brk1}$$

$$\frac{isBlocked(n,S,p)}{\langle S,(p\ AND\ break;\ \ q\ \bullet\ loop\ q)\rangle \xrightarrow{n} \langle S,(clear(p);nop)\rangle} \quad \text{(and-brk2)}$$

$$\frac{\langle S,p\rangle \xrightarrow{n} \langle S',p'\rangle}{\langle S,(p\ \bullet\ loop\ q)\rangle \xrightarrow{n} \langle S',(p'\ \bullet\ loop\ q)\rangle} \quad \text{(loop-comp-adv)}$$

$$\langle S,(nop\ \bullet\ loop\ p)\rangle \xrightarrow{n} \langle S,p\ \bullet\ loop\ p\rangle \quad \text{(loop-comp-nop)}$$

$$\langle S,(break;\ p\ \ \bullet\ loop\ p)\rangle \xrightarrow{n} \langle S,break\rangle \quad \text{(loop-comp-break)}$$

$$\frac{\langle S,p\rangle \xrightarrow{n} \langle S',p'\rangle}{\langle S,(p\ OR\ q)\rangle \xrightarrow{n} \langle S',(p'\ OR\ q)\rangle} \quad \text{(or-adv1)}$$

$$\frac{isBlocked(n,S,p) \qquad \langle S,q\rangle \xrightarrow{n} \langle S',q'\rangle}{\langle S,(p\ OR\ q)\rangle \xrightarrow{n} \langle S',(p\ OR\ q'\rangle} \quad \text{(or-adv2)}$$

$$\langle S,(nop\ AND\ q)\rangle \xrightarrow{n} \langle S,q\rangle \quad \text{(and-nop1)}$$

$$\langle S,(p\ AND\ nop)\rangle \xrightarrow{n} \langle S,p\rangle \quad \text{(and-nop2)}$$

$$\langle S,(break;p\ @\ loop\ p\ AND\ q)\rangle \xrightarrow{n} \langle S,clear(q)\rangle \quad \text{(and-brk1)}$$

$$\langle S,(nop\ OR\ q)\rangle \xrightarrow{n} \langle S,nop\rangle \quad \text{(or-nop1)}$$

$$\langle S,(p\ OR\ nop)\rangle \xrightarrow{n} \langle S,nop\rangle \quad \text{(or-nop2)}$$