Towards a coloured Petri nets semantics for a chronicle language

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Context

- Behaviour analysis of HLA distributed simulation
  - HLA: High Level Architecture: IEEE interoperability standard

- Using activities recognition techniques

- Activities are denoted by chronicles
Chronicle and their recognition

• Chronicles
  • Describe an event pattern
  • Events relationships:
    • Logical
    • Temporal

• Chronicle recognition:
  • Identify the chronicle patterns that are searched for in the observed event flow
  • Characteristic:
    • Find all instances of a searched chronicle
      • Store events that contributed to the recognition

occurrences of a followed by b
Chronicle language

• Logical operators
  • And : A & B
  • Or : A || B

• Temporal operators
  • Sequence : A B
  • Absence : (A B)-[C]
  • Absence and Sequence can be used to represent timed constraint
    • Minimum delay : A 5 B
    • Maximum delay (A B)-[5]

• Operator composition
  • (A || B) (C || D)
Chronicle modelling

• Using coloured Petri Nets
• Each chronicle event is represented by a transition
• Event occurrence is associated with firing the corresponding transitions

• We use specific nets (modelled with CPN tools):
  • One token per place (type CList or Boolean)
  • Complex list functions
  • colset Event with a|b|c|d;
  • colset ChronInst= list Event;
  • colset CList= list ChronInst;
Basic operators

- Basic event recognition

Event flow: \( a \ a \)
Basic operator: or

Diagram:

- A
- B
- Success

A instance [a] ins instance
B instance [b] ins instance
Success
CList

Diagram details:
- A instance
- B instance
- Success
- CList
- [a]
- [b]
Basic operators (A B) -[C]

- Absence operator (sequence)
Basic operators (A B) - [C]

Event flow: “a b b c b”
Basic operators (A B) -[C]

Event flow: “a b b c b”
Basic operators (A B) -[C]

Event flow: “a b b c b”
Basic operators (A B) - [C]

Event flow: “a b b c b”
Basic operators (A B) -[C]

Event flow: “a b b c b”
Basic net: time constraint

Minimum delay: A 5 B
Basic net: time constraint

Minimum delay: A 5 B

Event flow: “a 6 b”
Basic net : time constraint

Minimum delay : A $5$ B

Event flow : “a $6$ b”
Basic net: time constraint

Minimum delay: A 5 B

Event flow: “a 6 b”
Basic net: time constraint

Maximum delay: (A B)-[5]
Chronicles composition

• Goal: modelling the chronicle algebra

• We must model operators composition

• 2 ways:
  • Transition substitution
  • Places fusion
Transition Substitution

- Operators nets:

  Sequence

  Absence

  Conjunction

  Disjunction

- Event recognition:

  Start

  CList

  curr

  [curr != [] or else act]

  First

  BOOL

  true

  act

  instance

  instance^^H1st(a, curr)

  Success

  CList

  []
Transition substitution : the chronicle  A (B C)
Transition substitution : the chronicle  A (B C)
Recognition of A (B C)

Event flow: “a b b c”
Recognition of A (B C)

Event flow: “a b b c”
Recognition of A (B C)

Event flow: “a b b c”
Recognition of A (B C)

Event flow: “a b b c”
Event flow: “a b b c”
(A || B) (C || D) with transition substitution
Composition with place fusion

• Introducing another method to compose nets

• Motivations:
  • Easier than transition substitution
  • Visual correspondence with algebra operator composition
Chronicle A (B C) with place fusion
Chronicle A (B C) with place fusion

Event flow: “a b b c”
Chronicle A (B C) with place fusion

Event flow : "a b b c"
Chronicle A (B C) with place fusion

Event flow: “a b b c”
Chronicle A (B C) with place fusion

Event flow: “a b b c”
And operator with place fusion

\[ \text{B} \quad \text{Success} \]

\[ \text{Start} \quad \text{CList} \]

\[ \text{First} \quad \text{BOOL} \]

\[ \text{true} \quad \text{act} \]

\[ \text{instance} \]

\[ \text{curr} \quad [\text{curr} != \text{[]} \quad \text{orelse act}] \]

\[ \text{instance} \quad \text{^^H1st(a,curr)} \]

\[ \text{success} \quad \text{CList} \]

\[ \text{Temp} \quad \text{SuccessAB} \]

\[ \text{curr} \quad \text{chrAnd(curr)} \]

\[ \text{And} \quad \text{CList} \]

\[ \text{[]} \]

\[ \text{Start} \quad \text{CList} \]

\[ \text{First} \quad \text{BOOL} \]

\[ \text{true} \quad \text{act} \]

\[ \text{instance} \]

\[ \text{curr} \quad [\text{curr} != \text{[]} \quad \text{orelse act}] \]

\[ \text{instance} \quad \text{^^H1st(b,curr)} \]

\[ \text{success} \quad \text{CList} \]

\[ \text{Success} \quad \text{CList} \]

\[ \text{[]} \]
Or operator with place fusion
Absence operator with place fusion
Chronicle (A || B) (C || D)
Comparison

- Both methods produce the same results
  - Example with the A (B C) chronicle
- Both methods have the same expressiveness
- Place fusion nets are easier to read
- And easier to model with CPN tools
Conclusion

- We have nets for
  - Event recognition
  - Each operator
  - Formalise the composition
  - Two ways for the composition

- CRS/Onera works with HLA simulation

- Future works:
  - Integrating time representation in composition
  - Formalise the net subset
  - Extend the models with sub-chronicle and their absence
Application example

Chronicle detection