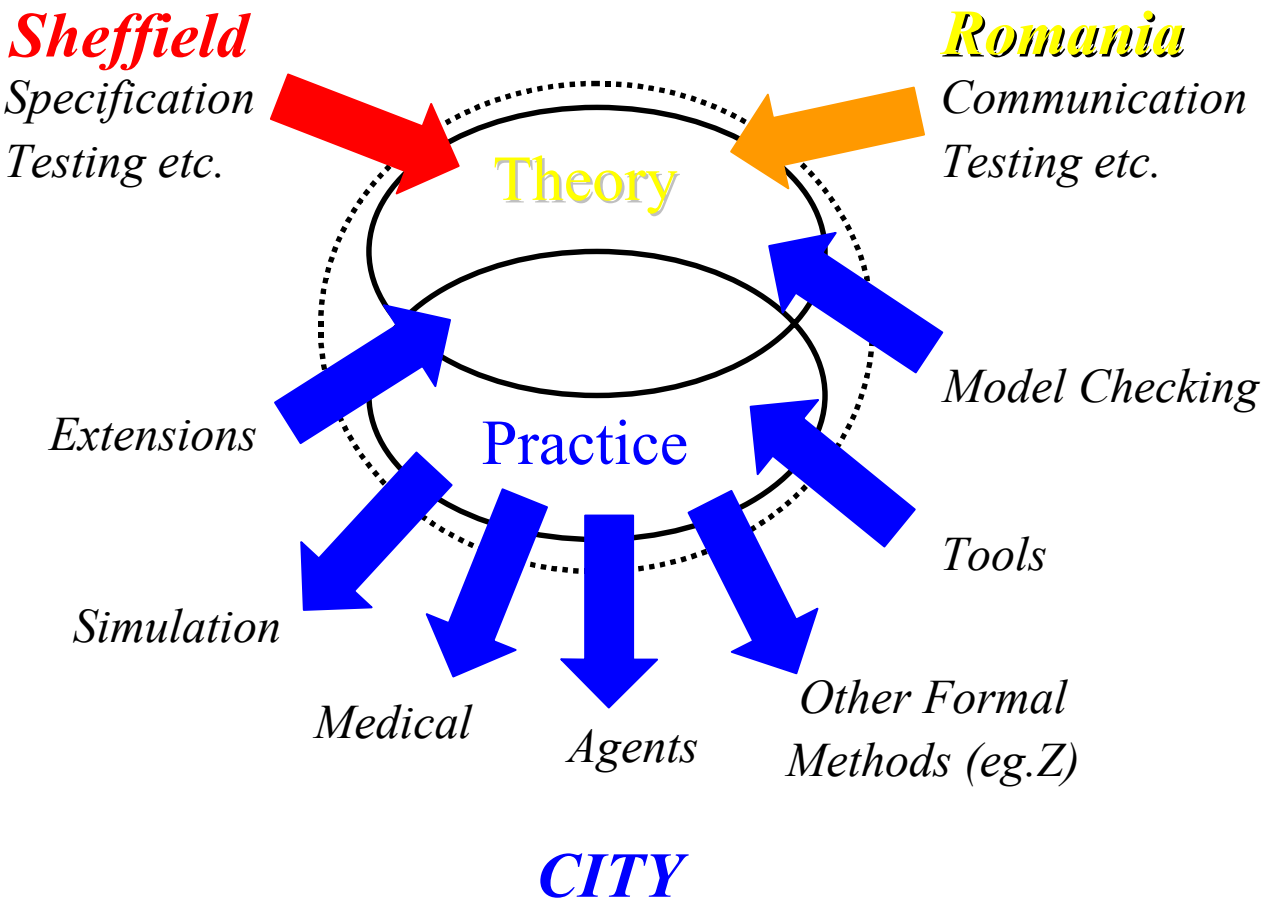
RESEARCH IN X-MACHINES



- **XMDL: A Language for coding X-Machine Specifications**
- **Automatic Code Generation: Translation of X-Machine Specifications to Prolog**
- **Translation of X-Machine Specifications to Z**
- **Using X-Machine to Model and Test Discrete Event Simulation Programs**
- **Model Checking of X-Machine Specifications**
- **Using X-Machine to Model Check Safety Critical Systems**
- **Communicating Object Oriented X-Machines**
- **Using X-machines to Model and Test Reactive Agents**
- **Tools for Test Case generation**
- **Tools for Animation**
- **Tools for Testing Programs resulted from X-Machine Specification**
- **Tools for Validating X-Machine Specifications**
- **Graphical Editor for the Development of X-Machine Specification**

A X-MACHINE EXAMPLE

A STACK WITH 10 ELEMENTS:

XM= (Σ, Γ, Q, M, Φ, F, q_0, m_0) where:

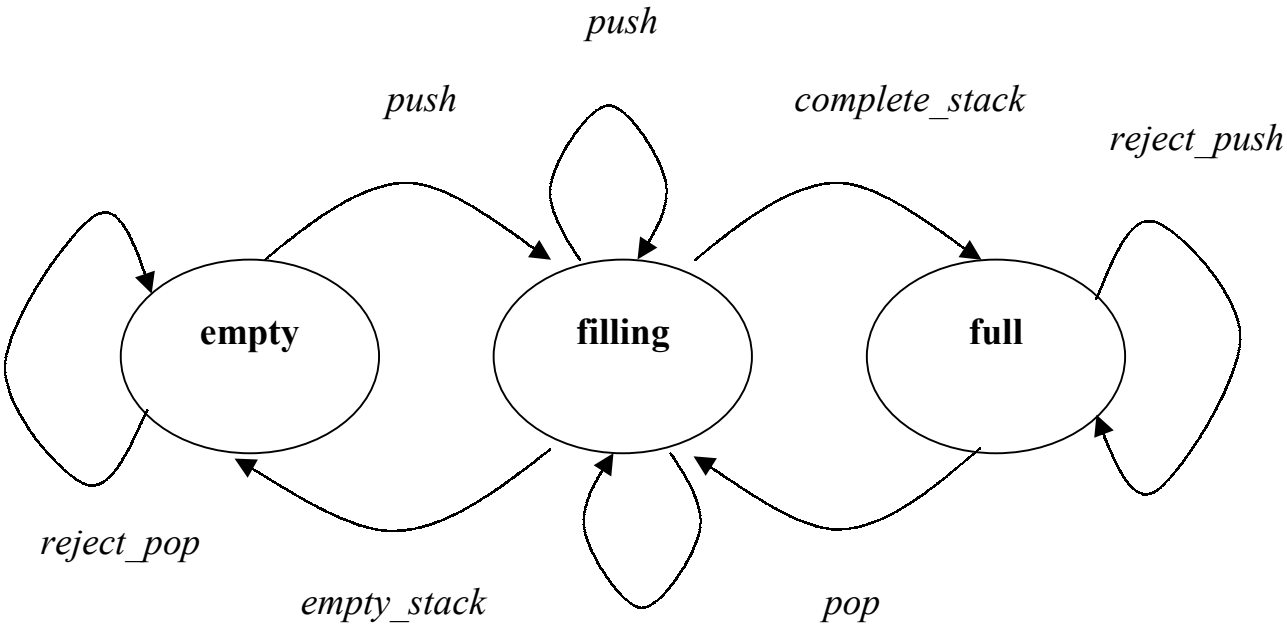
- **Σ, Γ** is the input and output finite alphabet respectively,
- **Q** is the finite set of states,
- **M** is the (possibly) infinite set called memory,
- **Φ** is the type of the machine *M*, a finite set of partial functions **φ** that map a memory state and an input to a new memory state and an output,

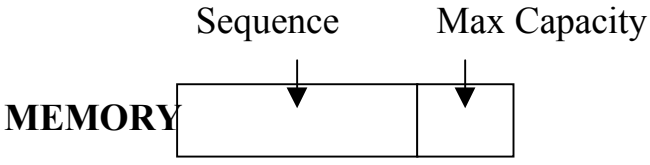
$$\varphi: M \times \Sigma \rightarrow \Gamma \times M$$

- **F** is the next state partial function that given a state and a function from the type **Φ**, denotes the next state. **F** is often described as a transition state diagram.

$$F: Q \times \Phi \rightarrow Q$$

- q_0 and m_0 are the initial state and memory respectively.





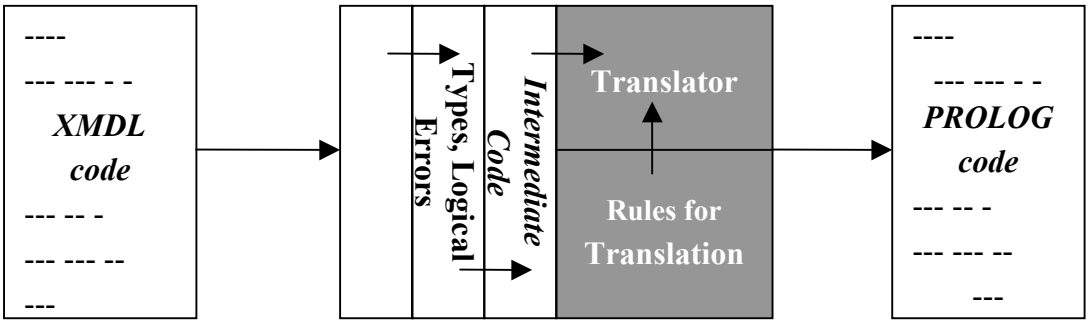
```
#model stack.

#basic_types = [ELEMENT].

#type capacity = Natural.
#type action = {down_arrow, up_arrow}.
#type messages = {ElementPushed, ElementPoped, StackFull, StackEmpty,
RejectStackFull, RejectStackEmpty}.
#type stack = sequence_of ELEMENT.
#type allelements = ELEMENT union {no_element}.

#states = {empty, filling, full}.

#memory (stack, capacity).

#init_state {empty}.
#init_memory (nil, 10).

#input (action, allelements).
#output (messages, allelements).
```

```
#fun function name INPUT PARAMETERS=
if condition expression then
 OUTPUT PARAMETERS.
```

```
#fun function name (input parameters tuple, memory tuple)=
if condition expression then
 (output parameter tuple, new memory tuple)
where
body expression.
```

```
#fun reject_pop ((up_arrow, no_element), (nil, ?c))=
     ((RejectStackEmpty, no_element), (nil, ?c)).

#fun push ((down_arrow,?element), (?stack, ?c))=
if ?number < ?c then
     ((ElementPushed,?element),(<?element :: ?stack>, ?c))
where
     ?number <- cardinality <?element :: ?stack>.

#fun reject_push ((down_arrow,?x), (?stack,?c))=
if ?number = ?c then
     ((RejectStackFull, ?x), (?stack, ?c))
where
     ?number <- cardinality ?stack.

#transition (empty, reject_pop)=empty.
#transition (empty, push)=filling.
#transition (filling, push)=filling.
#transition (filling, pop)=filling.
#transition (filling, complete_stack)=full.
#transition (filling, empty_stack)=empty.
#transition (full, reject_push)=full.
#transition (full, pop)=filling.

#end.
```

TRANSLATING XMDL CODE:



Rule of Translation (example):

Whenever you identify this (written in XMDL):

```
#transition ( a state, a function )= a new state.
```

output this (which is the equivalent in Prolog):

```
transition( a state, a function , a new state).
```

PARSING XMDL CODE
DEFINITE CLAUSE GRAMMAR (example):

```
transition -->
     ['#transition'],
     ['('],
     statename,
     [','],
     functionname,
     [')'],
     ['='],
     statename.

statename --> constant.

functionname --> constant.

constant -->
     allowedchar.
constant -->
     allowedchar,
     constant.

allowedchar--> letter.
allowedchar--> digit.
allowedchar--> special_symbol.

letter-->      [a].
. . .
letter-->      [z].

digit-->       [0].
. . .
digit-->       [9].

special_symbol-->   ['_'].
```

“NORMAL” PROLOG:

```
parse(_,S,[]):- transition(S,[]).
```

QUERY:

Is the phase #transition (empty, reject_pop)=empty syntactically correct?

```
?- parse( [#transition,(,e,m,p,t,y,‘,’,r,e,j,e,c,t,_,p,o,p,),=,e,m,p,t,y],
          []).
yes
```

DEFINITE CLAUSE GRAMMAR
(Same Example with Parameter and Action)

```
transition -->
     ['#transition'],
     ['('],
     statename(S1),
     [','],
     functionname(F),
     [')'],
     ['='],
     statename(S2)                    { my_output_transition(S1,F,S2) }.


statename(X) --> constant(X).

functionname(X) --> constant(X).

allowedchar(L)-->   letter(L).
allowedchar(D)-->   digit(D).

. . .
```

"NORMAL" PROLOG:

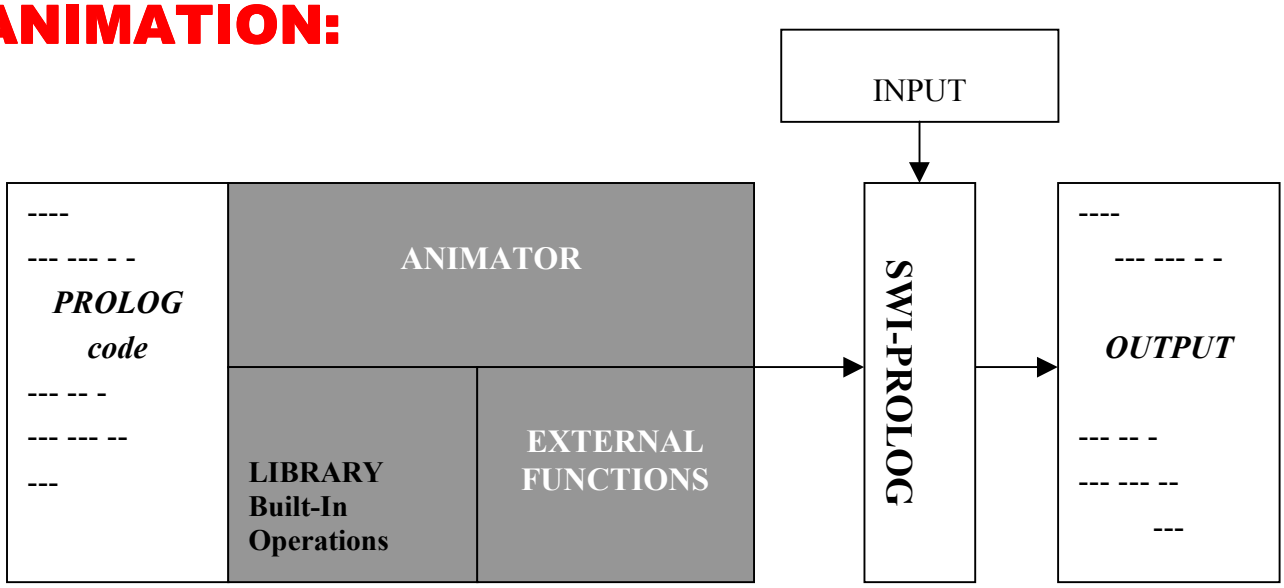
```
parse(_,S,[]):- transition(S,[]).

my_output_transition( From, With, Where):-
     write('transition('),
     write(From),
     write(','),
     write(With),
     write(','),
     write(Where),
     write(').'),
     nl.
```

QUERY:

Is the phase #transition (empty, reject_pop)=empty syntactically correct?
If so, what is the translation in PROLOG?

```
?- parse( [#transition,(,e,m,p,t,y,',',r,e,j,e,c,t,_,p,o,p,),=,e,m,p,t,y],
          []).

transition(empty,reject_pop,empty).

yes
```

ANIMATION:




```
?- animatex.
State : empty Input ?[down_arrow,1].
------------------------------------------------------------------------
Applied Function : push
Output: [elementpushed, 1] Memory : [[1], 10] At State :filling
------------------------------------------------------------------------
State : filling Input ?[up_arrow,no_element].
------------------------------------------------------------------------
Applied Function : empty_stack
Output: [stackempty, no_element] Memory : [[], 10] At State :empty
------------------------------------------------------------------------
State : empty Input ?[up_arrow,no_element].
------------------------------------------------------------------------
Applied Function : reject_pop
Output: [rejectstackempty, no_element] Memory : [[], 10] At State :empty
------------------------------------------------------------------------
State : empty Input ?[down_arrow,1].
------------------------------------------------------------------------
Applied Function : push
Output: [elementpushed, 1] Memory : [[1], 10] At State :filling
------------------------------------------------------------------------
State : filling Input ?[d_arrow,2].
WARNING: Invalid Input!

WARNING: No Function Applicable!
State : filling Input ?[down_arrow,3].
------------------------------------------------------------------------
Applied Function : push
Output: [elementpushed, 3] Memory : [[3, 2, 1], 10] At State :filling
```

TRANSLATION TO Z:

STACK MEMORY

Stack: seq ELEMENT

Capacity: N

STACK STATE

CurrentState: Q

Initialise

□ STACK MEMORY

□ STACK STATE

Stack′ = <>

Capacity′ = 10

CurrentState′ = idle

Push

□ STACK MEMORY

□ STACK STATE

In? : INPUT

Out!: OUTPUT

In? = (down_arrow, El) ∧

<El> ^ Stack < Capacity ∧

Stack′ = <El> ^ Stack ∧

Capacity′ = Capacity ∧

CurrentState′ = next(CurrentState, Push) ∧

Out! = (“ElementPushed”, El)