Designing Interactive Systems I

Ten Golden Rules: Timeouts, Responsiveness, Notations

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Winter Semester ’20/’21

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Review

- What are the Ten Golden Rules of Interface Design?

Ten Golden Rules: Timeouts

Timeouts are Evil!

Timeouts are Evil!

Timeouts: Station Search

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Timeouts: Station Search

Timeouts: Writing “Hi” on T9

Timeouts: Writing “Hi” on T9

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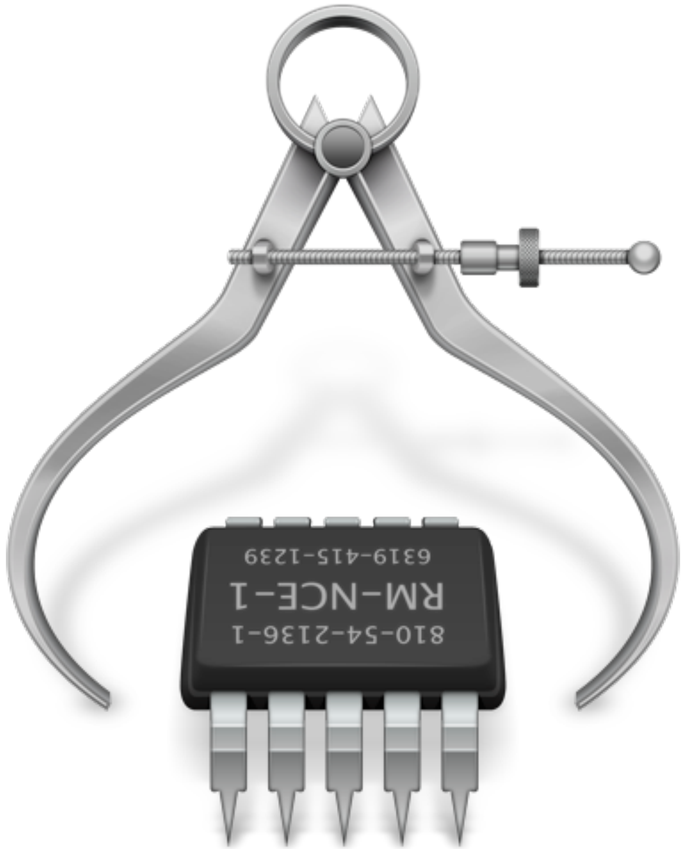
The Top 5 Performance Hits

Hard Disk Access

Large Memory Footprint



Interlocking Threads

Unsuitable Data and Control Structures

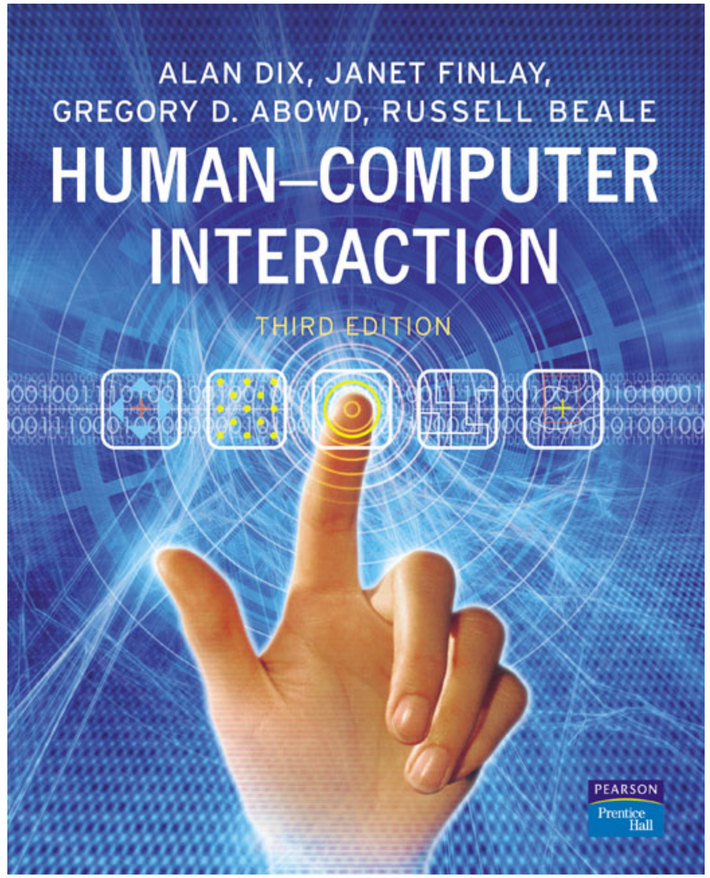
Reinventing the Wheel

Reinventing the Wheel

Notations

Interaction Design Notations

- Alan Dix et al.: Human-Computer Interaction, 3rd ed. (2003), Chapter 16



Back to BASICs

```
Print "Please enter a number”
INPUT n
Print "The square of",n,"is",n*n
```

- What are the problems with using such a notation to specify a dialog?

Why UI Specification Languages

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- System and user decisions are hard to distinguish
- Error checking on inputs dominates and complicates code
- First step: bundling I/O in classes/procedures
- Second step: Use a more efficient, readable language to specify the dialog
  - A priori to design the dialog
  - As part of the implementation (executable spec.)

Specifying User Interfaces

- Problem: Describe the proposed design of a user interface
- Approach: natural/semi-formal/formal languages
- Many standard computer science techniques apply
- The more modern the UI, the harder to describe textually, depending on modality and UI style

Grammars

- Mostly BNF-like

```
expr ::= empty | atom expr | '(' expr ')' expr
```

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- E.g., Shneiderman's multiparty grammar

```
<Session>        ::=   <U: Opening> <C: Responding>
<U: Opening>     ::=   LOGIN <U: Name>
<U: Name>        ::=   <U: string>
<C: Responding>  ::=   HELLO [<U: Name>]
```

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```

- Great for command-line UIs, e.g., banking ATMs, Unix commands
- Less suitable for GUIs

Grammars

- Regular expressions
    - `select-line click click* double-click`

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- E.g., Unix “copy” command synopsis:

```
cp [-R [-H | -L | -P]] [-f | -i | -n] [-pv] source_file target_file
cp [-R [-H | -L | -P]] [-f | -i | -n] [-pv] source_file ... target_dir
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Grammars

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recursion policies

overwrite policies

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recursion policies

overwrite policies

- Short and precise, but hard to read, requires additional information about semantics

Production Rules

- Unordered list of rules: `if condition then action`
  - Condition based on state or pending events
  - Every rule always potentially active
- Good for concurrency
- Bad for sequence

Event-based Production Rules

Event-based Production Rules

```
select-line → first
```

Event-based Production Rules

```
select-line → first
click first → rest
```

Event-based Production Rules

```
select-line → first
click first → rest
click rest → rest
```

Event-based Production Rules

```
select-line → first
click first → rest
click rest → rest
double-click rest → <draw line>
```

Event-based Production Rules

```
select-line → first
click first → rest
click rest → rest
double-click rest → <draw line>
```

- Note:
  - Events added to list of pending events
  - ‘first’ and ‘rest’ are internally generated events

Event-based Production Rules

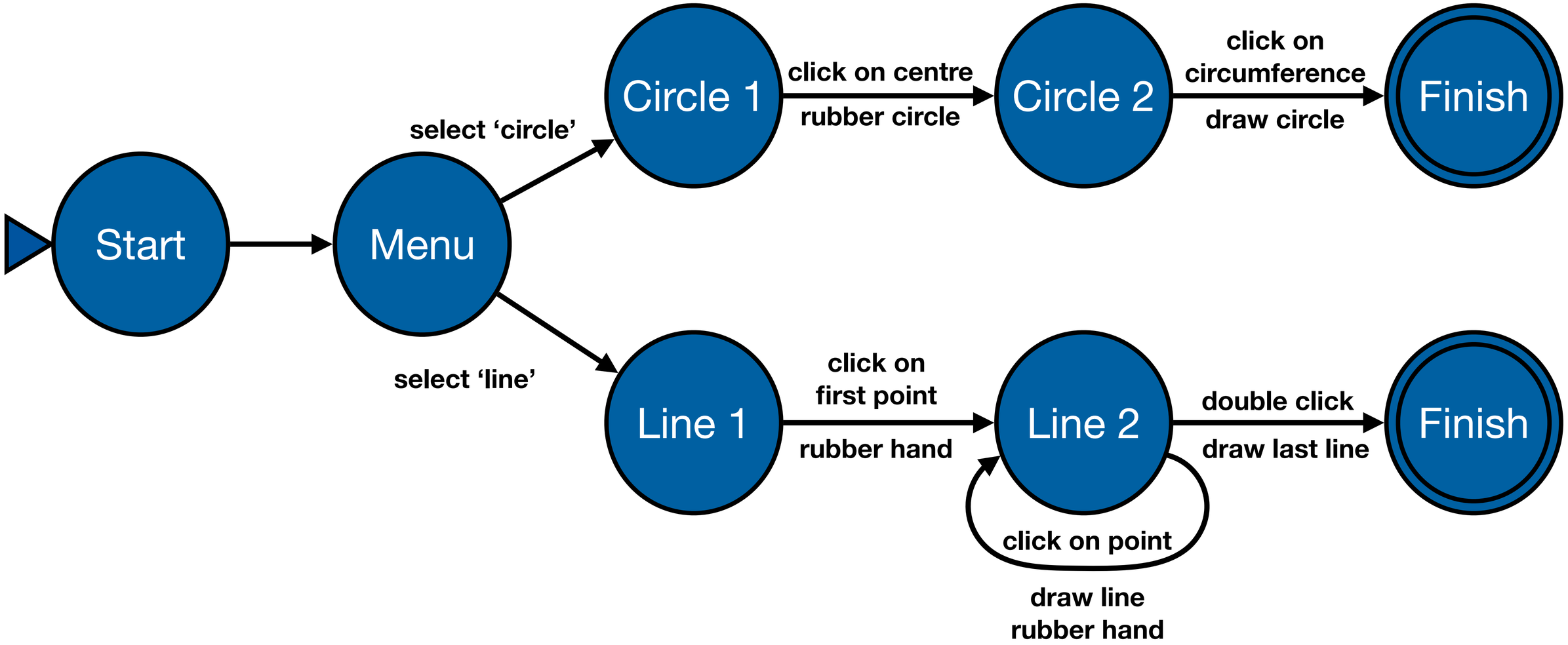
```
select-line → first
click first → rest
click rest → rest
double-click rest → <draw line>
```

- Note:
  - Events added to list of pending events
  - ‘first’ and ‘rest’ are internally generated events
- Bad at state!

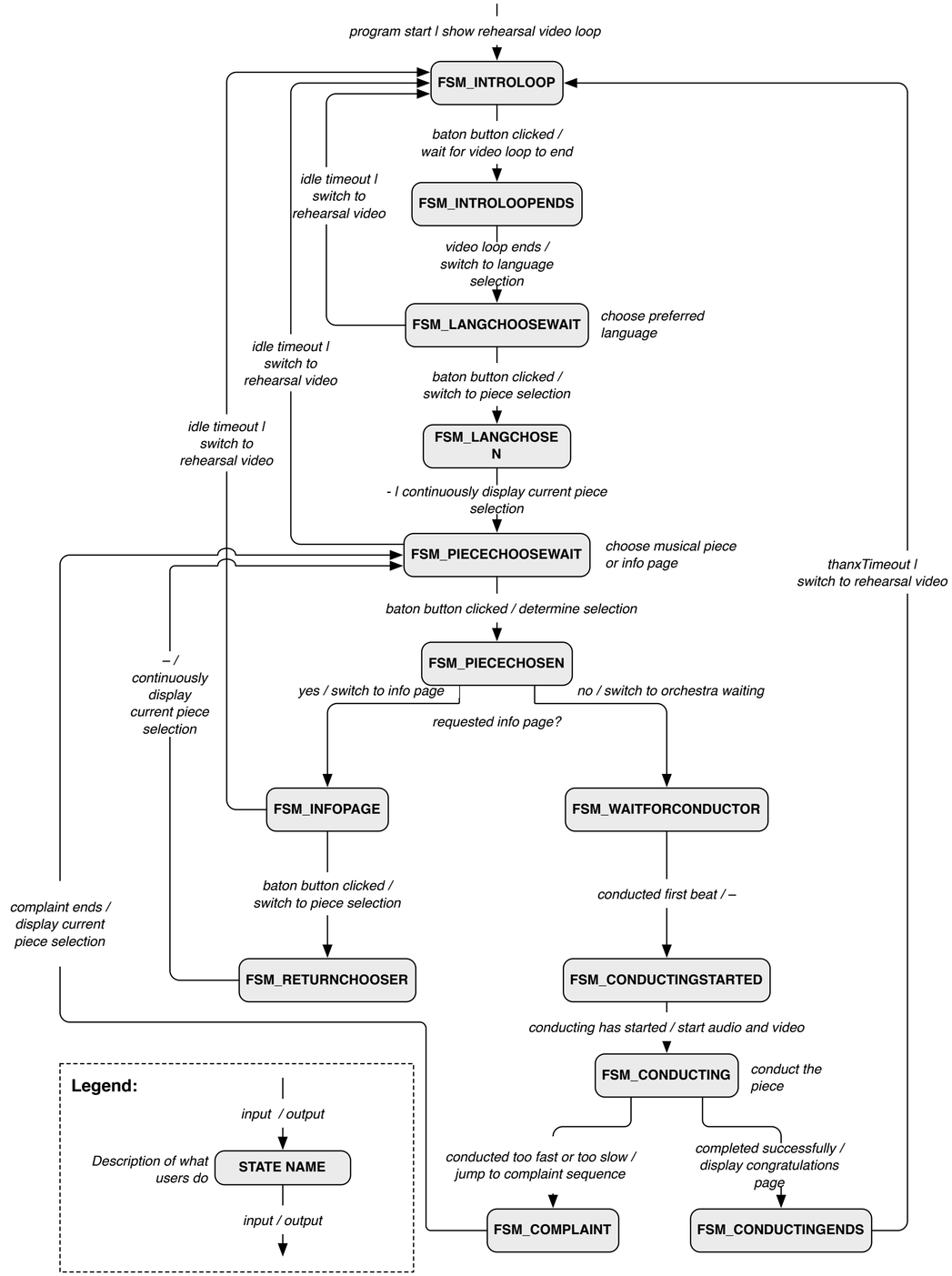
Graph Notations: STNs

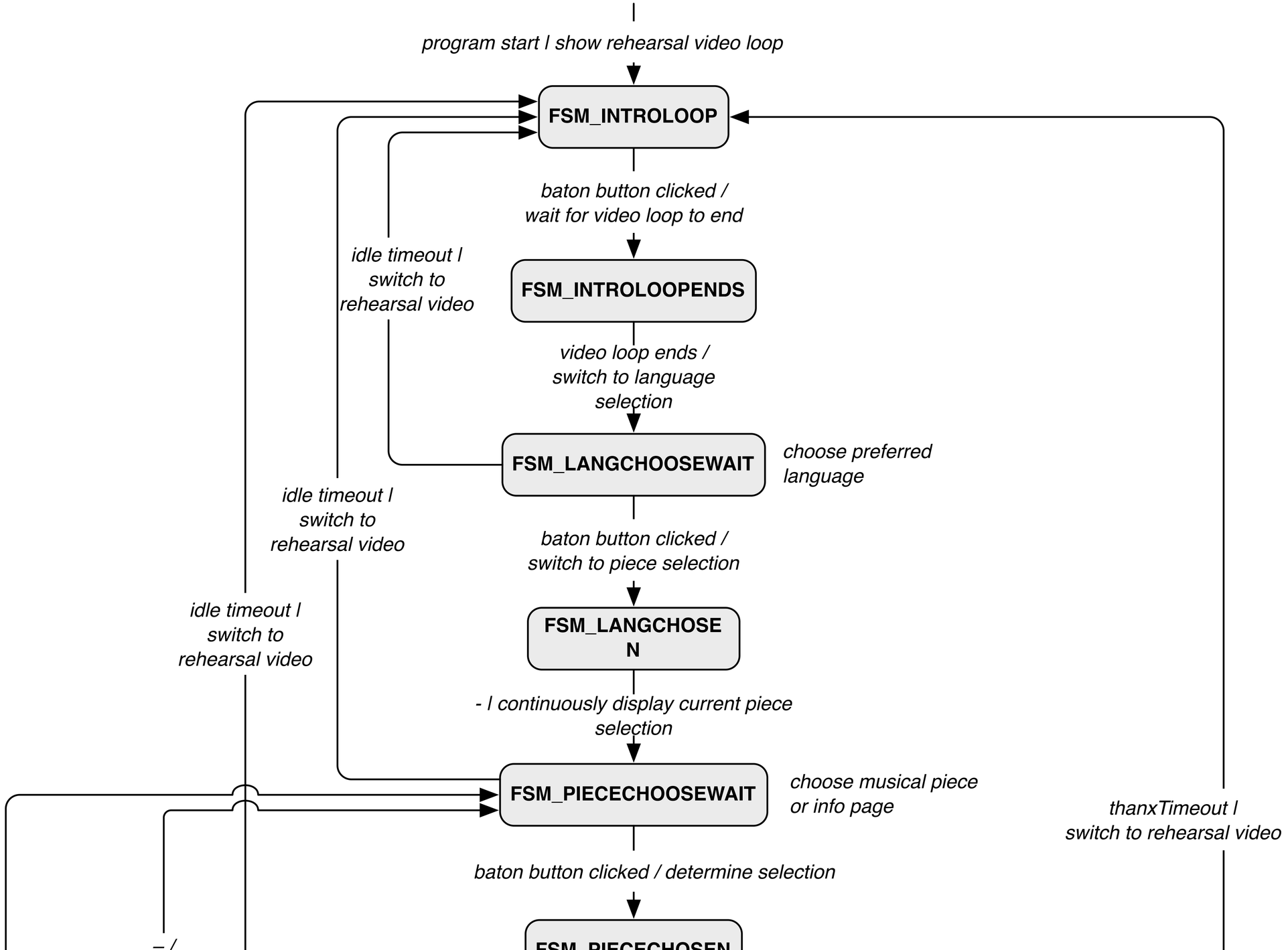
- State Transition Networks (STNs)
  - Most common tool to specify dialogs
  - Established format (since 1960s)
- Consisting of:
  - **States** (usually the system waiting for some user action)
  - **Transitions** (which have a **user action** and a **system response** associated with them)
- Describes **sequences** of user actions and system responses

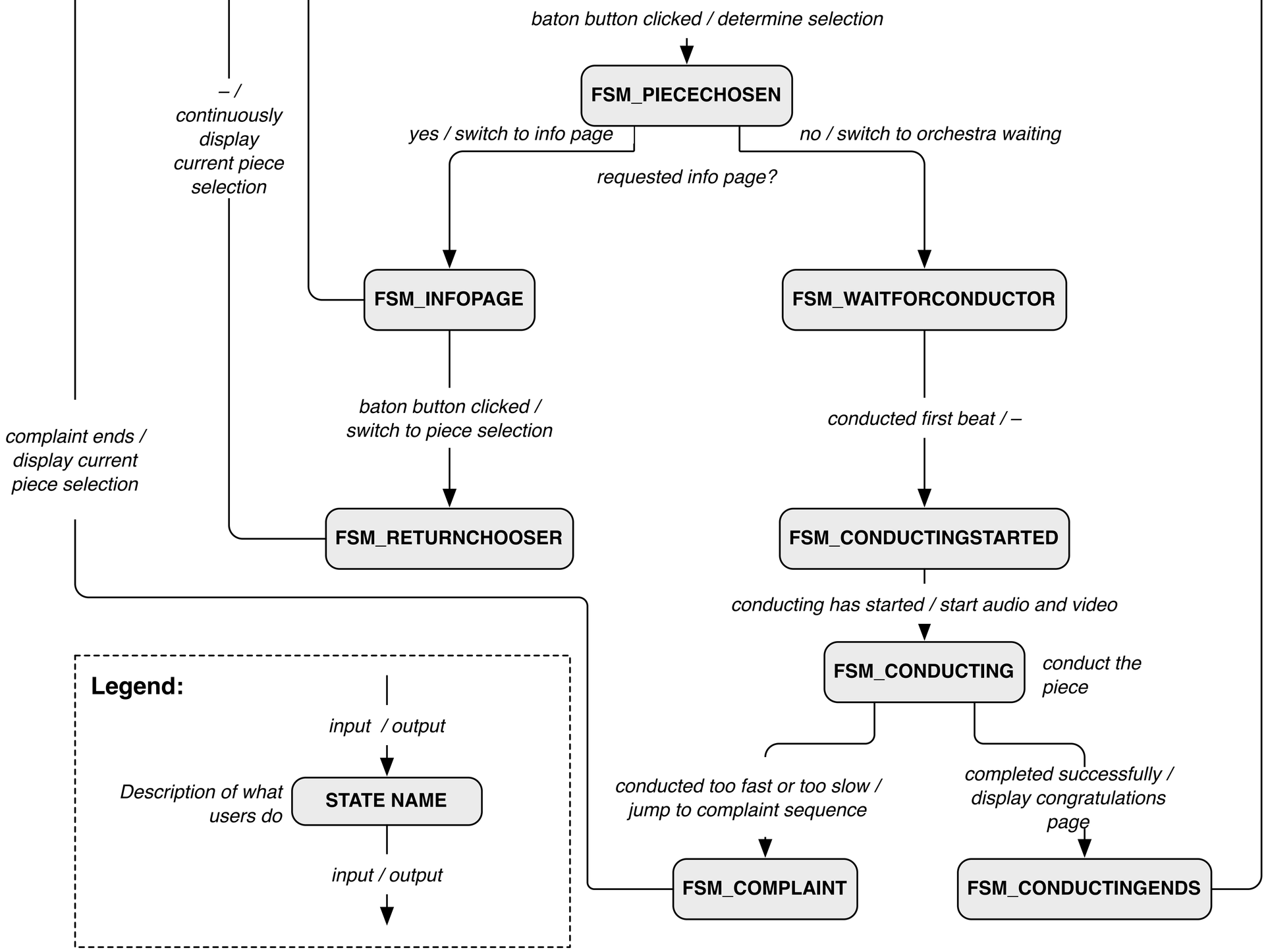
Graph Notations: STNs

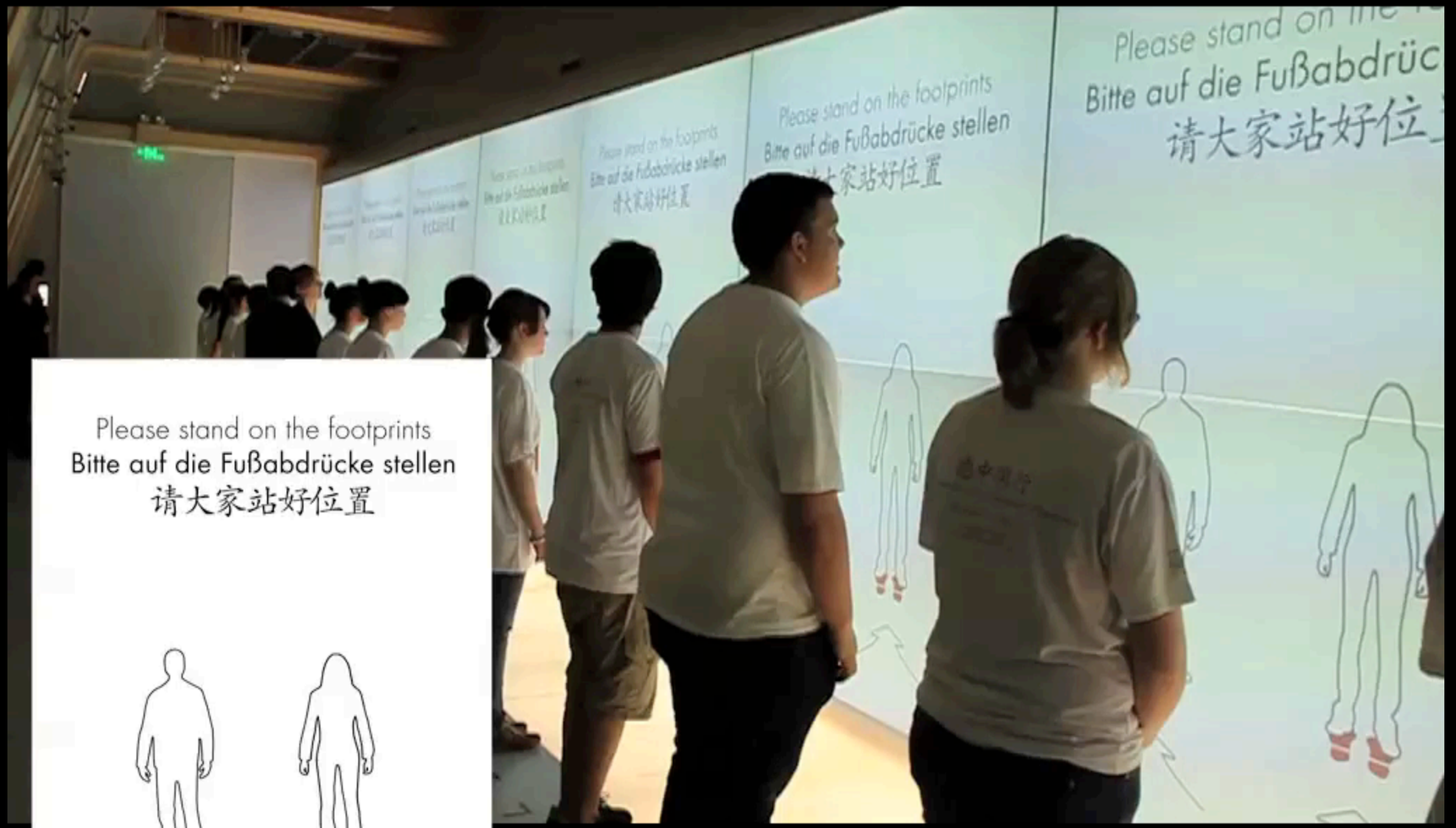


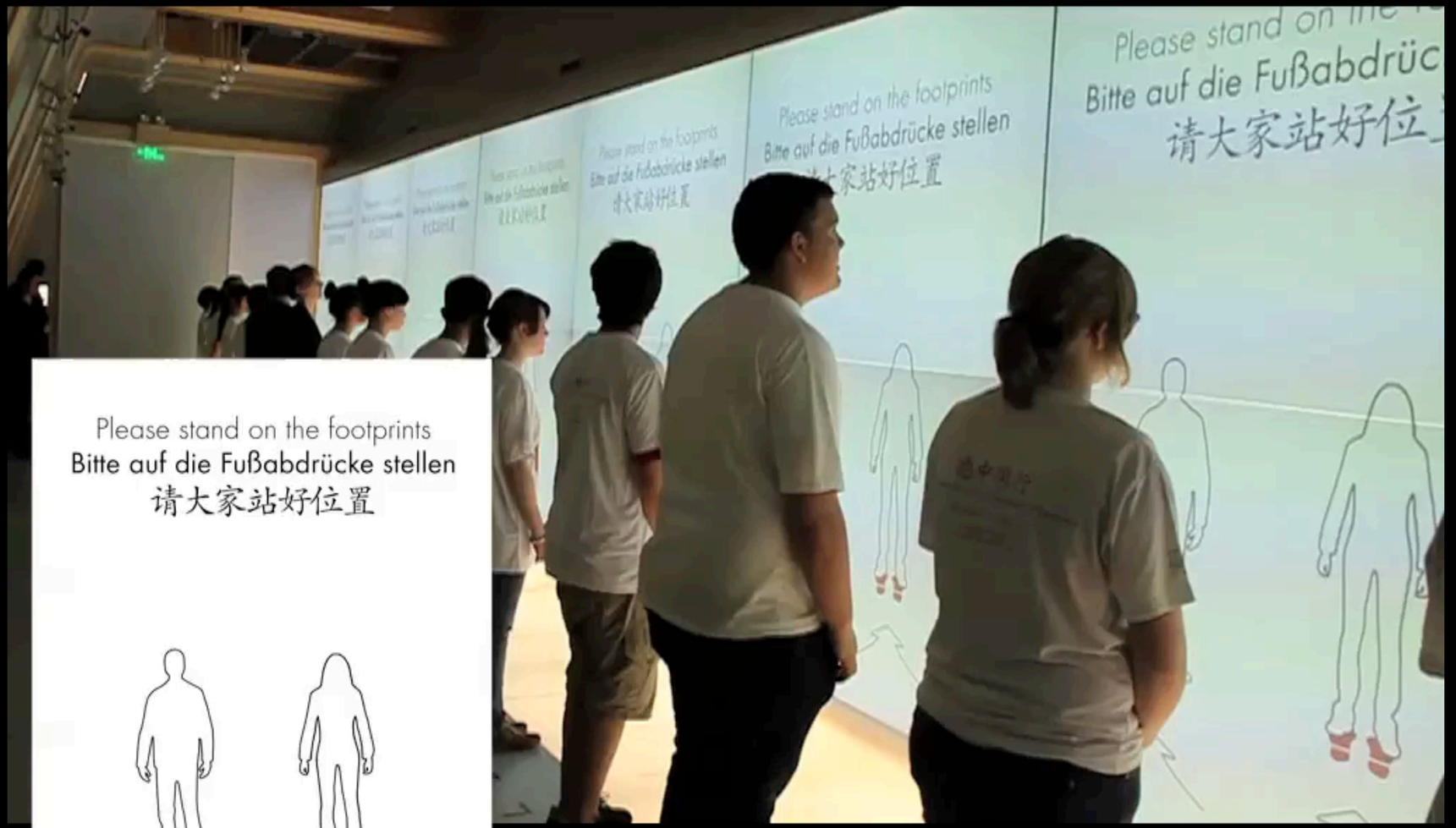
Example: STN for Personal Orchestra Dialog




program start / show rehearsal video
FSM_INTROLOOP
baton button clicked /
wait for video loop to end
idle timeout /
switch to
rehearsal video
FSM_INTROLOOPENDS
video loop ends /
switch to language
selection
FSM_LANGCHOOSEWAIT
choose preferred
language
idle timeout /
switch to
rehearsal video
baton button clicked /
switch to piece selection
idle timeout /
switch to
rehearsal video
FSM_LANGCHOSE
N
- / continuously display current piece
selection
FSM_PIECECHOOSEWAIT
choose musical piece
or info page
thanxTimeout /
switch to rehearsal video
baton button clicked / determine selection


baton button clicked / determine selection
FSM_PIECECHOSEN
– / continuously display current piece selection
yes / switch to info page
no / switch to orchestra waiting
requested info page?
FSM_INFOPAGE
FSM_WAITFORCONDUCTOR
baton button clicked / switch to piece selection
conducted first beat / –
complaint ends / display current piece selection
FSM_RETURNCHOOSER
FSM_CONDUCTINGSTARTED
conducting has started / start audio and video
FSM_CONDUCTING
conduct the piece
conducted too fast or too slow / jump to complaint sequence
completed successfully / display congratulations page
FSM_COMPLAINT
FSM_CONDUCTINGENDS
Legend:
input / output
Description of what users do
STATE NAME
input / output


Please stand on the footprints
Bitte auf die Fußabdrücke stellen
请大家站好位置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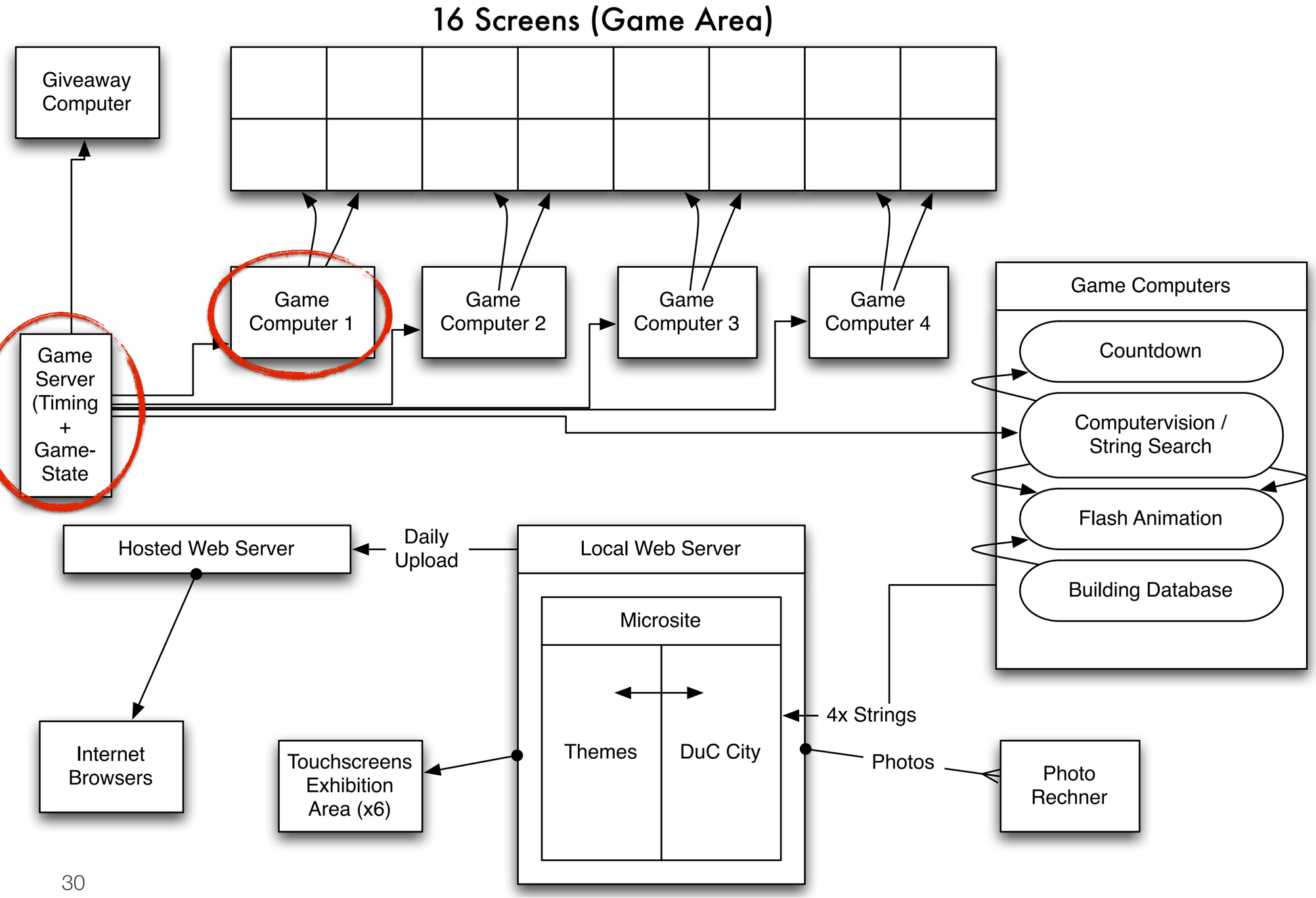
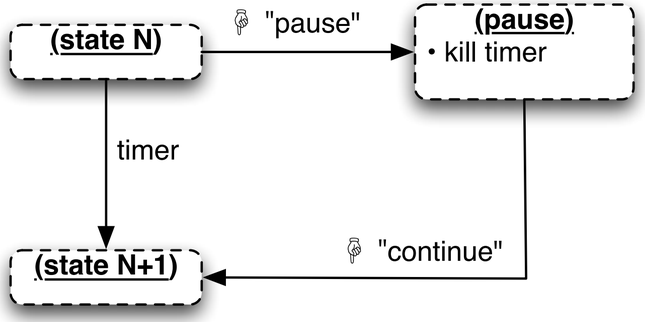
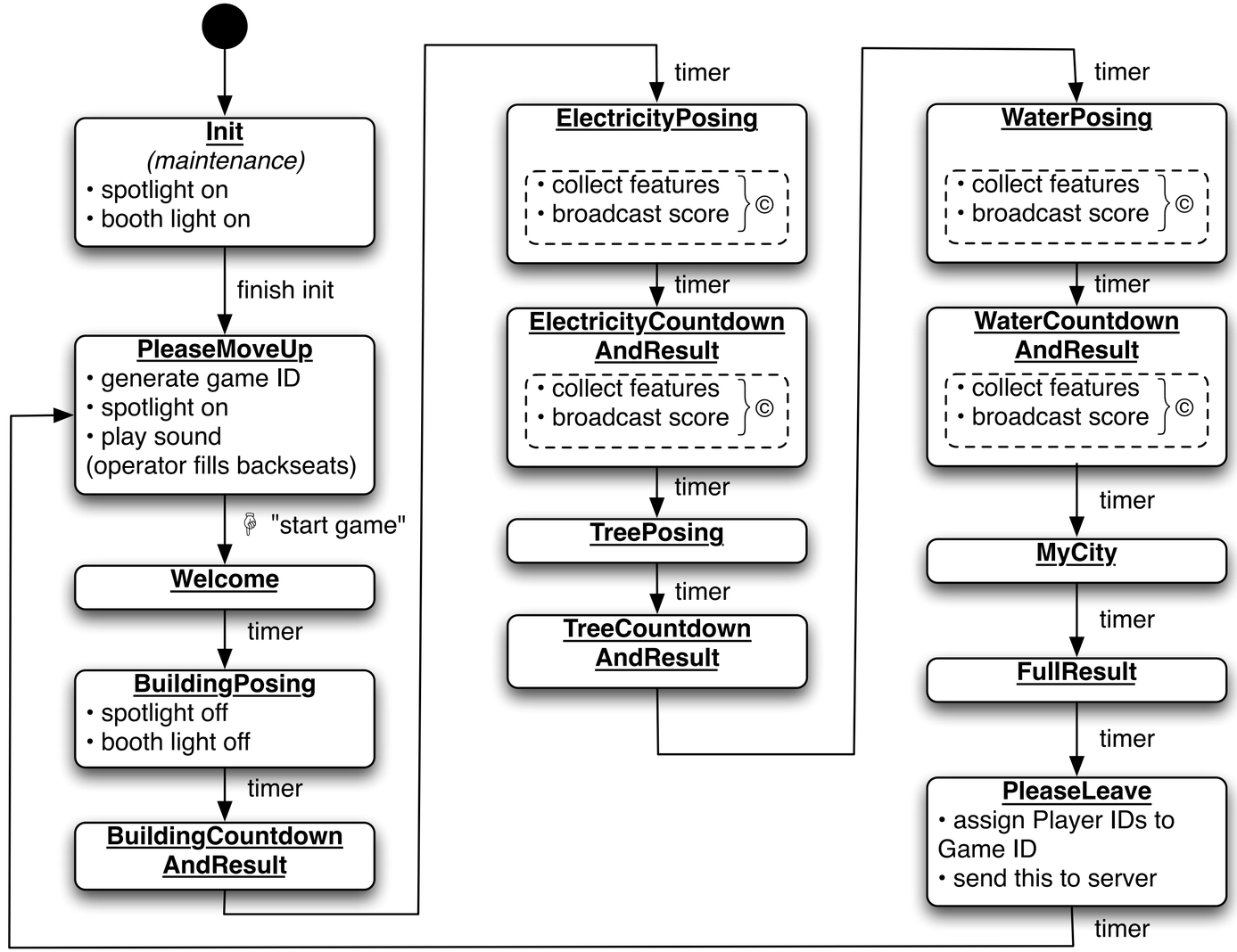
Silhouettes Components



Silhouettes: Server STN

- Unconventional notation (agreed upon in the team)

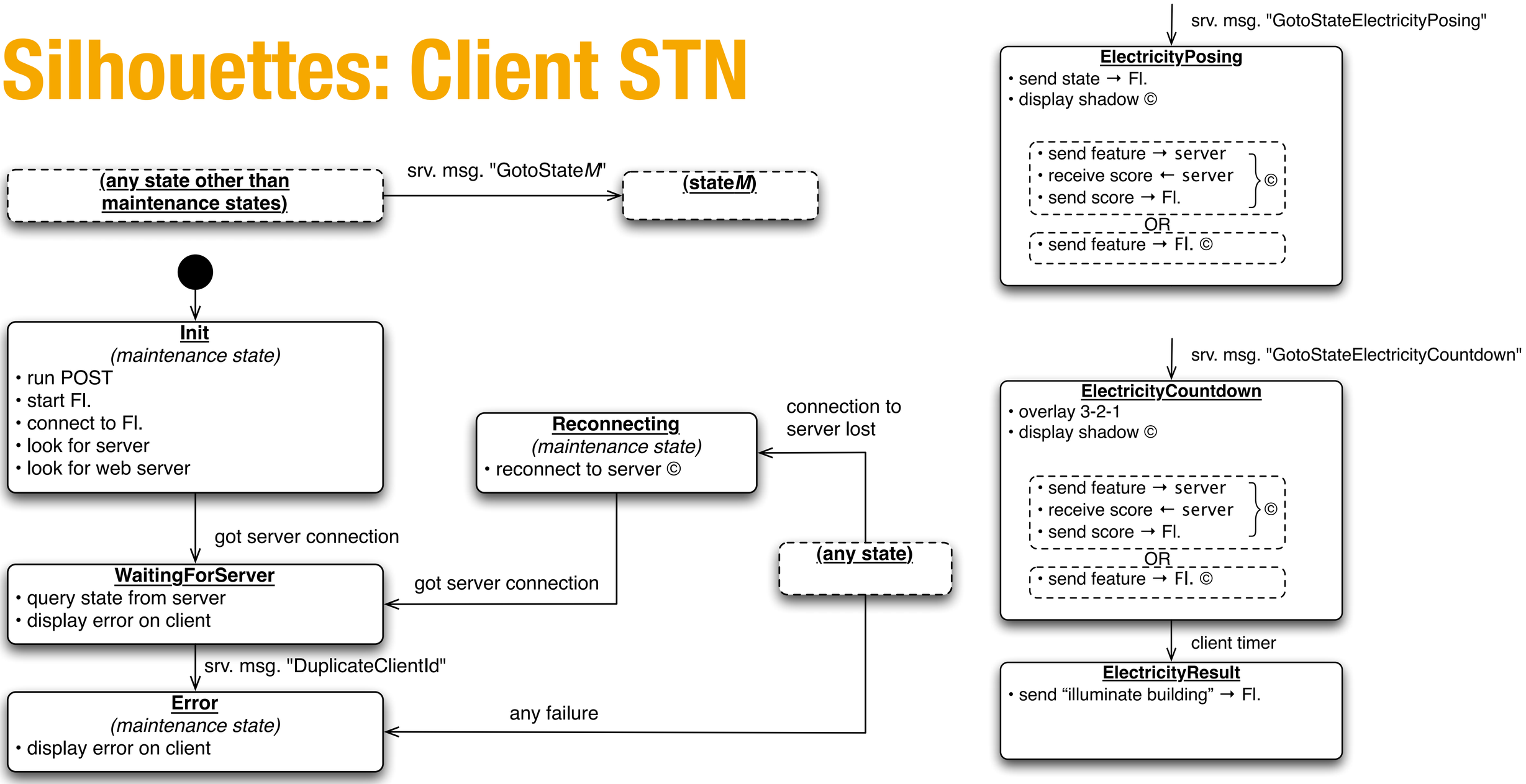




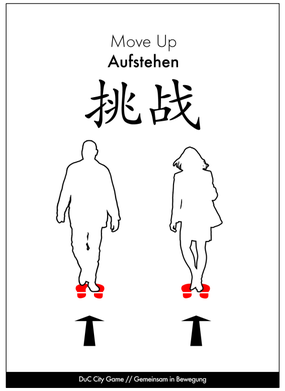
Legend:
: operator pushes button

Note:
• server is responsible to fade sound in each state

Silhouettes: Client STN

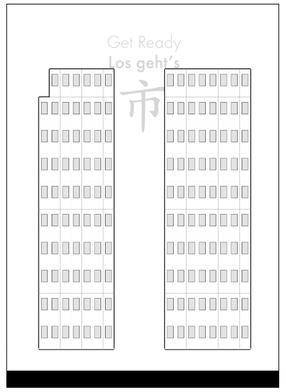


Game Storyboard

Visuals	Description	Server State/Action	Client State/Light
	Waiting people will be asked to move up to the front and take their positions on the indicated spots.	**PleaseMoveUp** • generate game ID • spotlight on • play sound (operator fill backseats)	DMX msg. - fade **in** spots on indicated footprints on the floor
		srv. msg. "GotoStatePleaseMoveUp"	
		PleaseMoveUp • send state → FI.	
		"start game" by button push 	
 	Playing people will be presented a a welcome screen. People from the outer waiting queue will take their seats in the inside waiting booths.	**Welcome** 	DMX msg. - fade **out** spots on indicated foot prints on the floor - fade **in** light in the waiting booths
		srv. msg. "GotoStateWelcome"	
		Welcome • send state → FI. • display mnemonics	
			DMX msg. - fade **out** light in the waiting booths

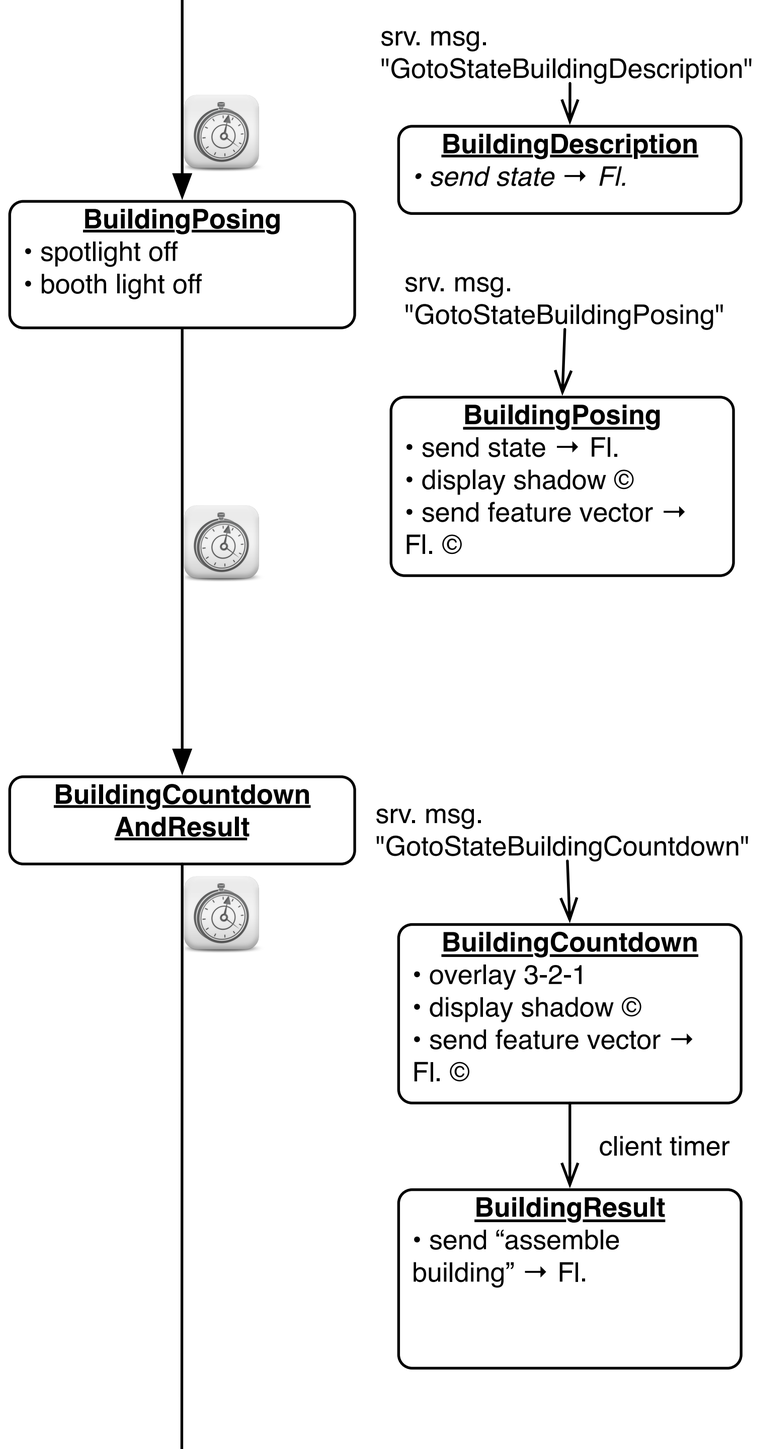
Iconic illustrations will remind the player how to create buildings by their shadows.

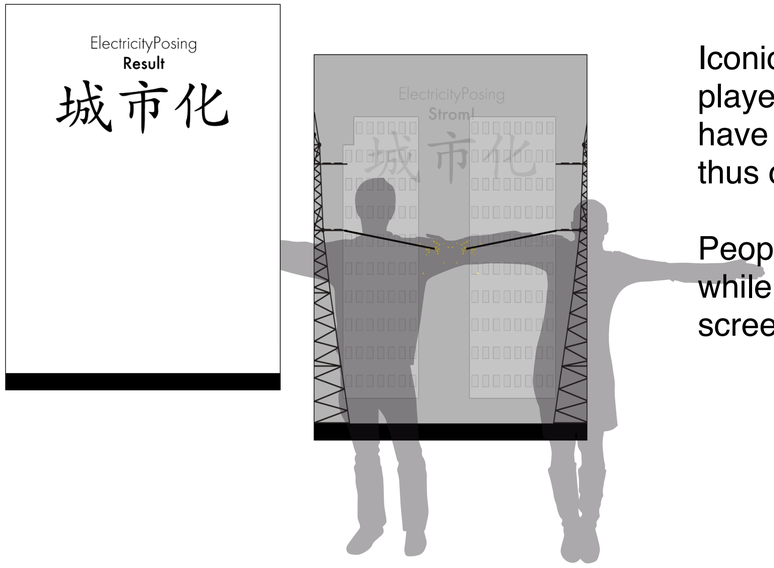
People will see their shadows while posing in front of the screens.



A countdown will indicate that shadows will be "frozen".

People will see the representation of their shadows as buildings.



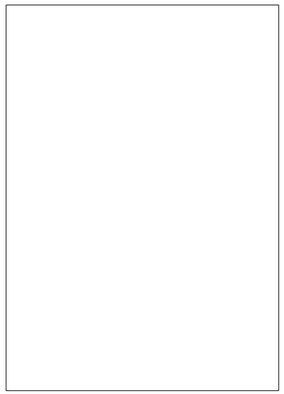


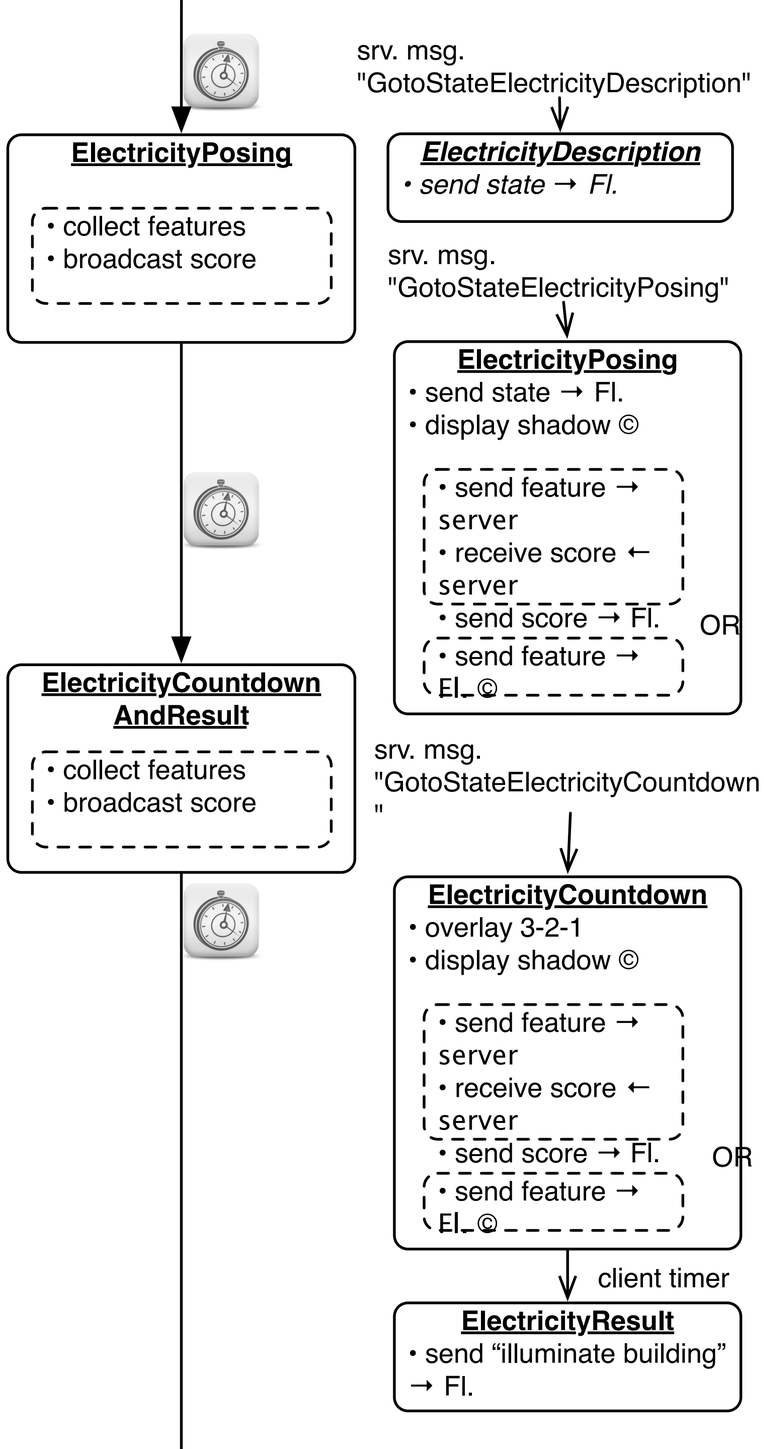
Iconic illustrations will remind the player how to pose in order to have their shadows overlap and thus create a power line.

People will see their shadows while posing in front of the screens.

A countdown will indicate that shadows will be "frozen".

People will see illuminated buildings in 4 different versions??



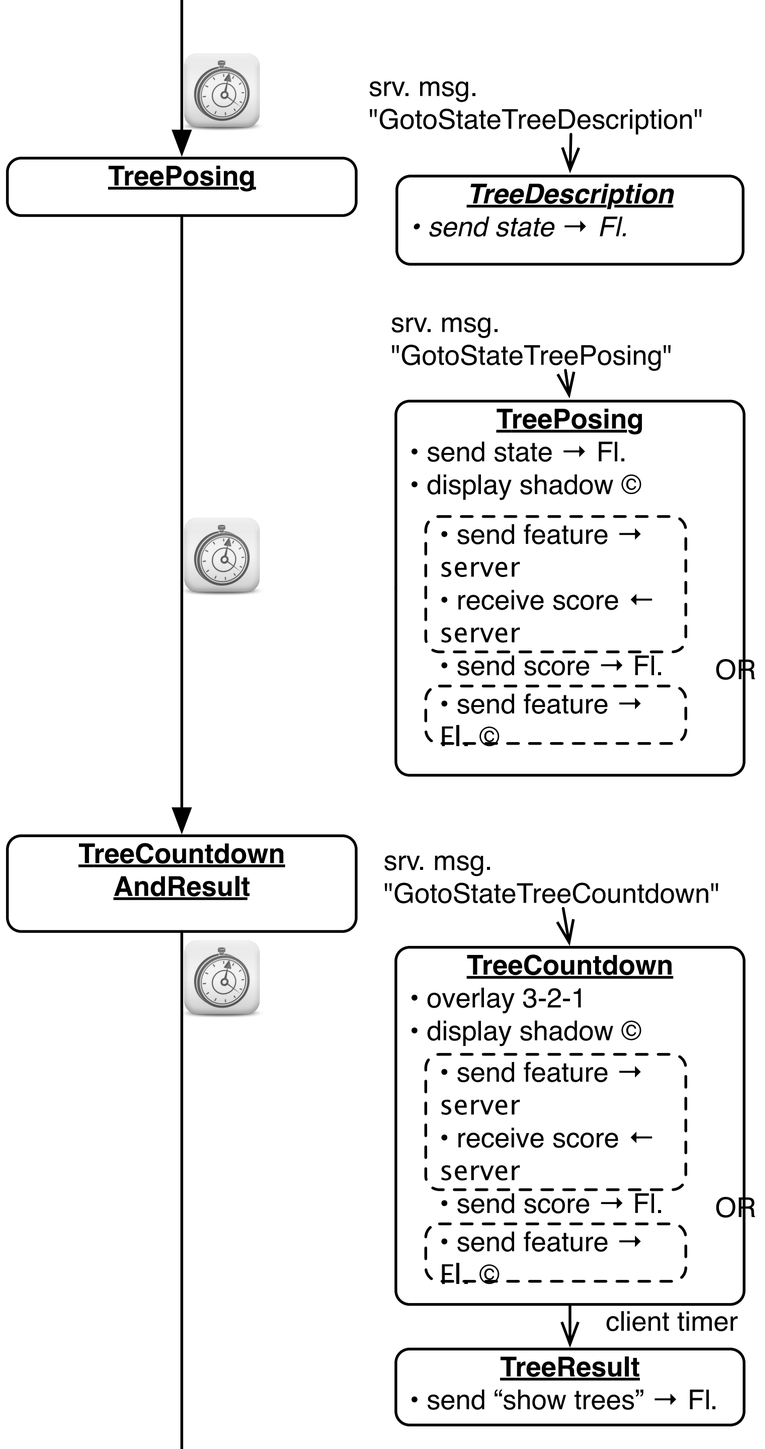


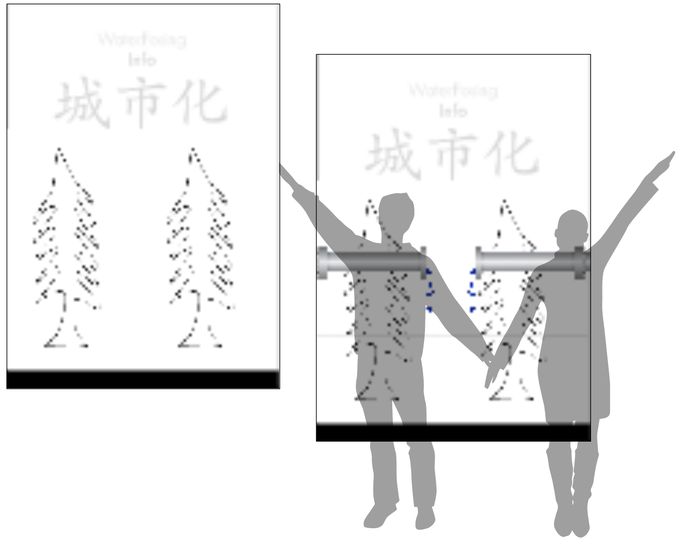
Iconic illustrations will remind the player how to create trees by their shadows.

People will see their shadows while posing in front of the screens.

A countdown will indicate that shadows will be "frozen".

People will see the representation of their shadows as trees.



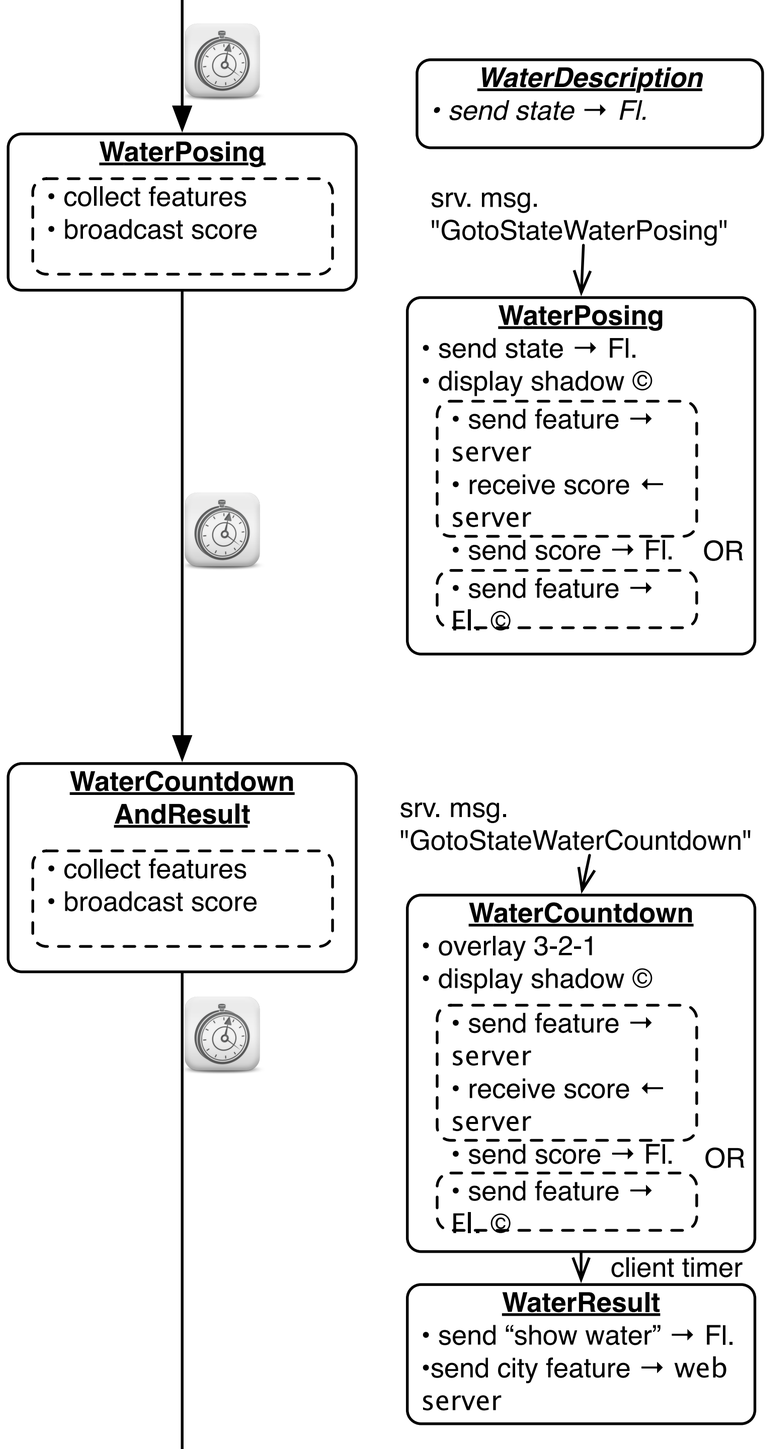


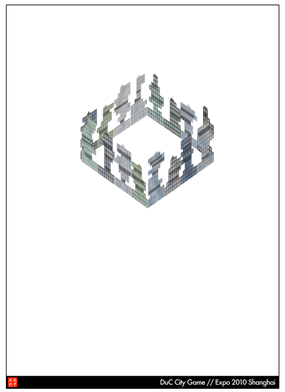
Iconic illustrations will remind the player how to pose in order to have their shadows overlap and thus create a water line.

People will see their shadows while posing in front of the screens.

A countdown will indicate that shadows will be "frozen".

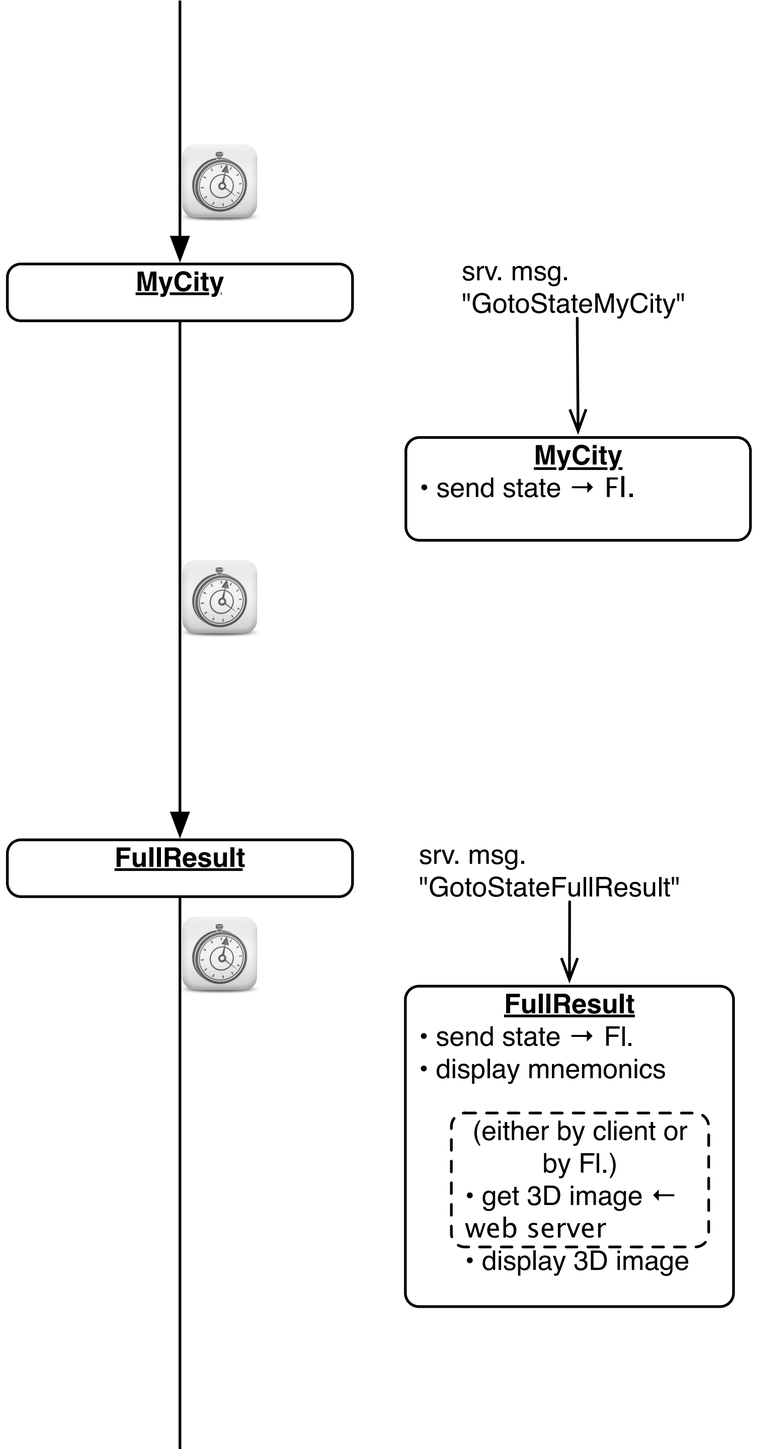
People will see the trees that they created with different green colours/trees with leaves?





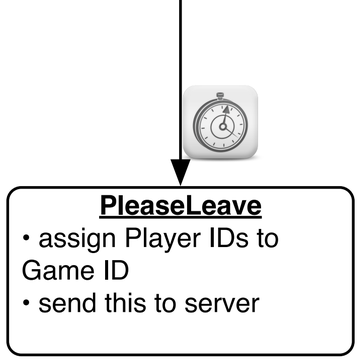
People will see a animation of what will happen with their skyline.

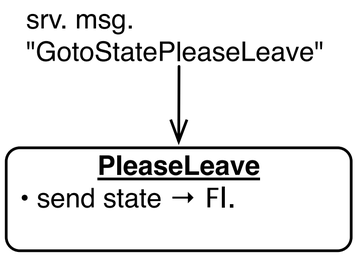
People will see their city block with the block number and the URL of the DuC Website.



People will be asked to move out.

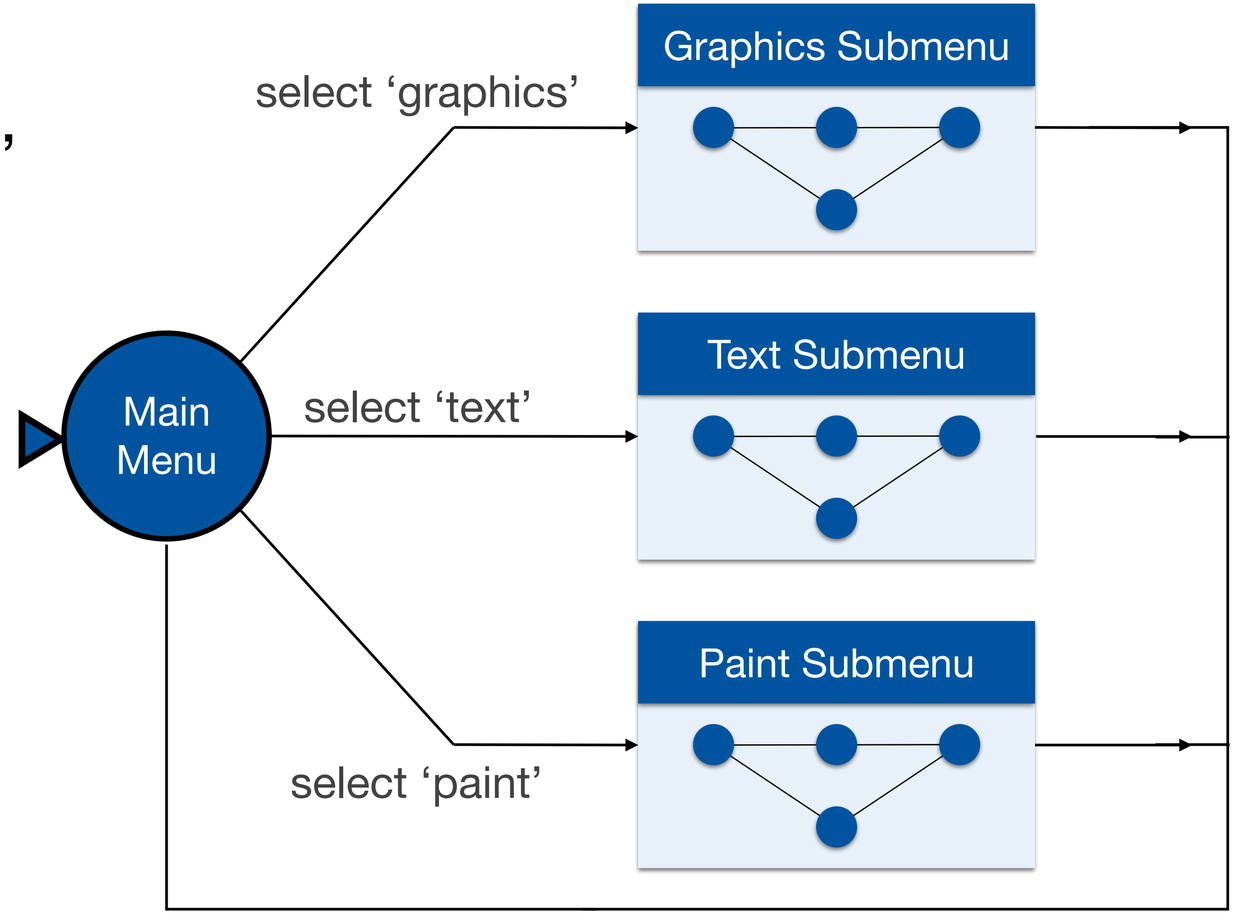
Beyond the playing area, visitors can deepen their understanding of city concepts at individual interactive stations before leaving the pavilion.





Hierarchical STNs

- Start and Finish states serve to glue an STN for a sub dialog (e.g., a certain menu selection) into a larger dialog (e.g., operating the application in general)
- Same expressive power as STNs, just more convenient
- The dialog structure of an entire system can be specified this way

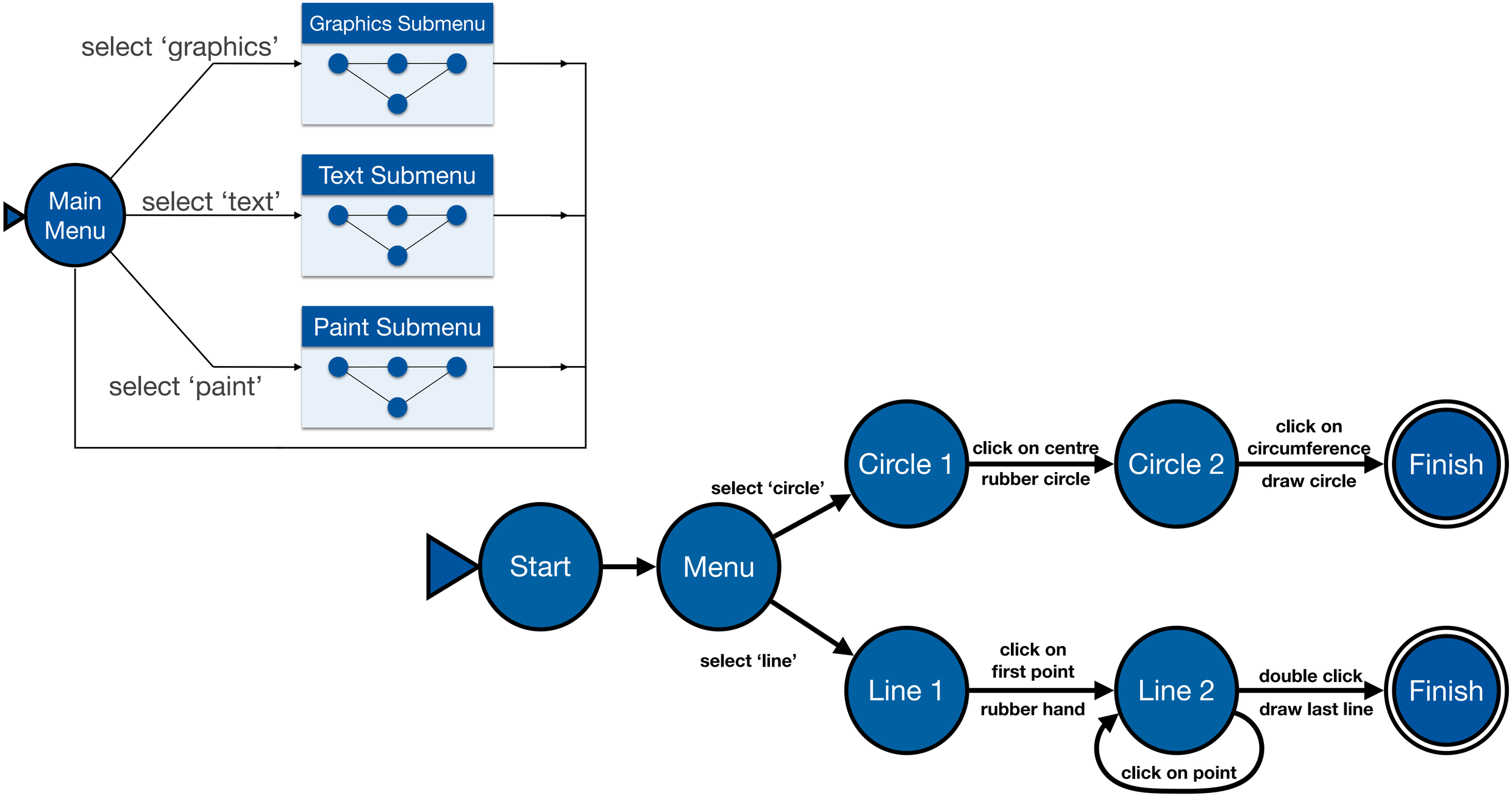


Using STNs in Prototyping

- Create a simple STN for the dialogs envisioned
- Create one UI snapshot (sketch if paper prototype) per state (label it with the state name)
- Include offscreen area for annotations and to include extra buttons simulating user actions that do not correspond to simple clicks on the current screen
- When walking the user through your paper prototype, consult the STN to find out how to respond to each user action

Using STNs in Prototyping

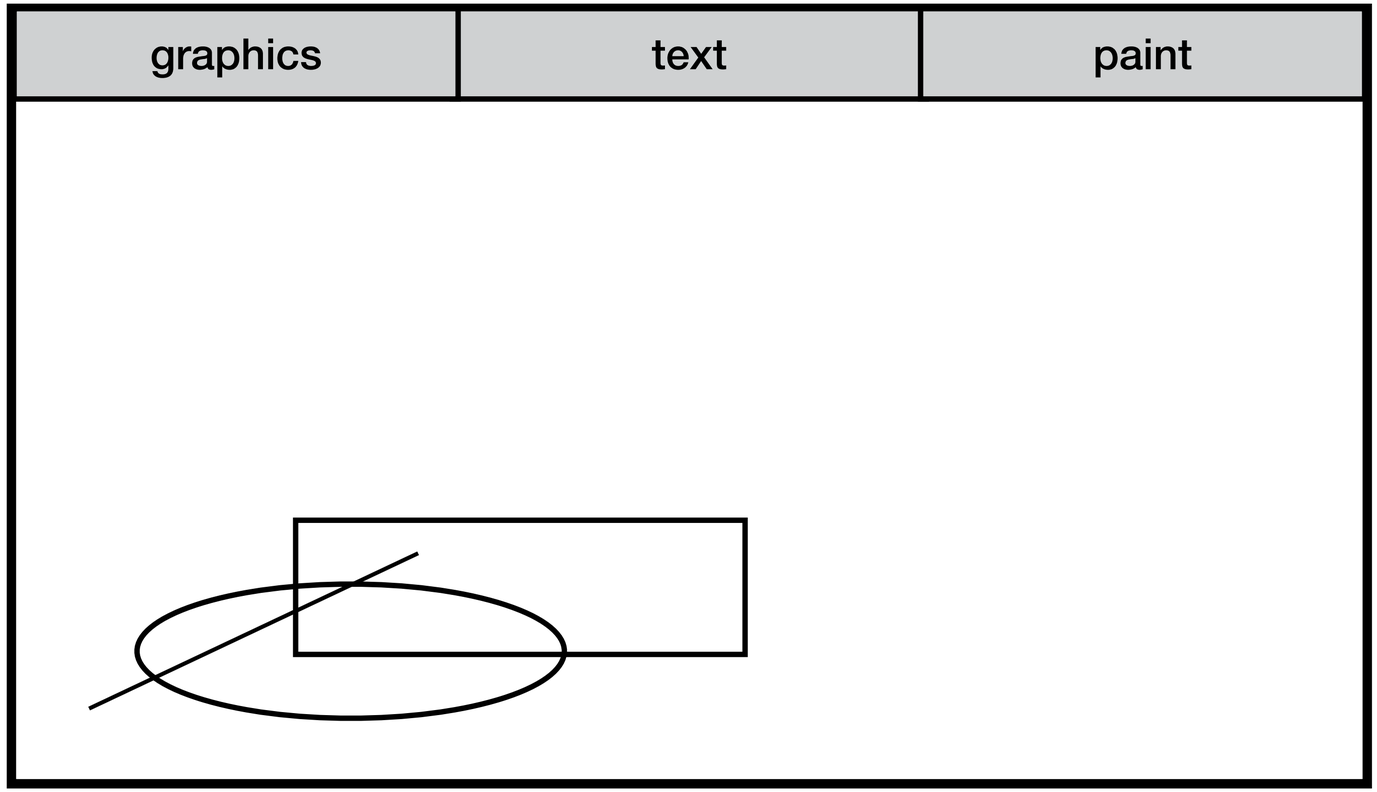
- Alternative: Let the computer “execute” the STN to run the prototype
- Use tools such as Keynote, PowerPoint



Using STNs in Prototyping

Adapted from “Human–Computer Interaction” by Dix, Finlay, Abowd, and Beale, Chapter 8

Current state: Main Menu



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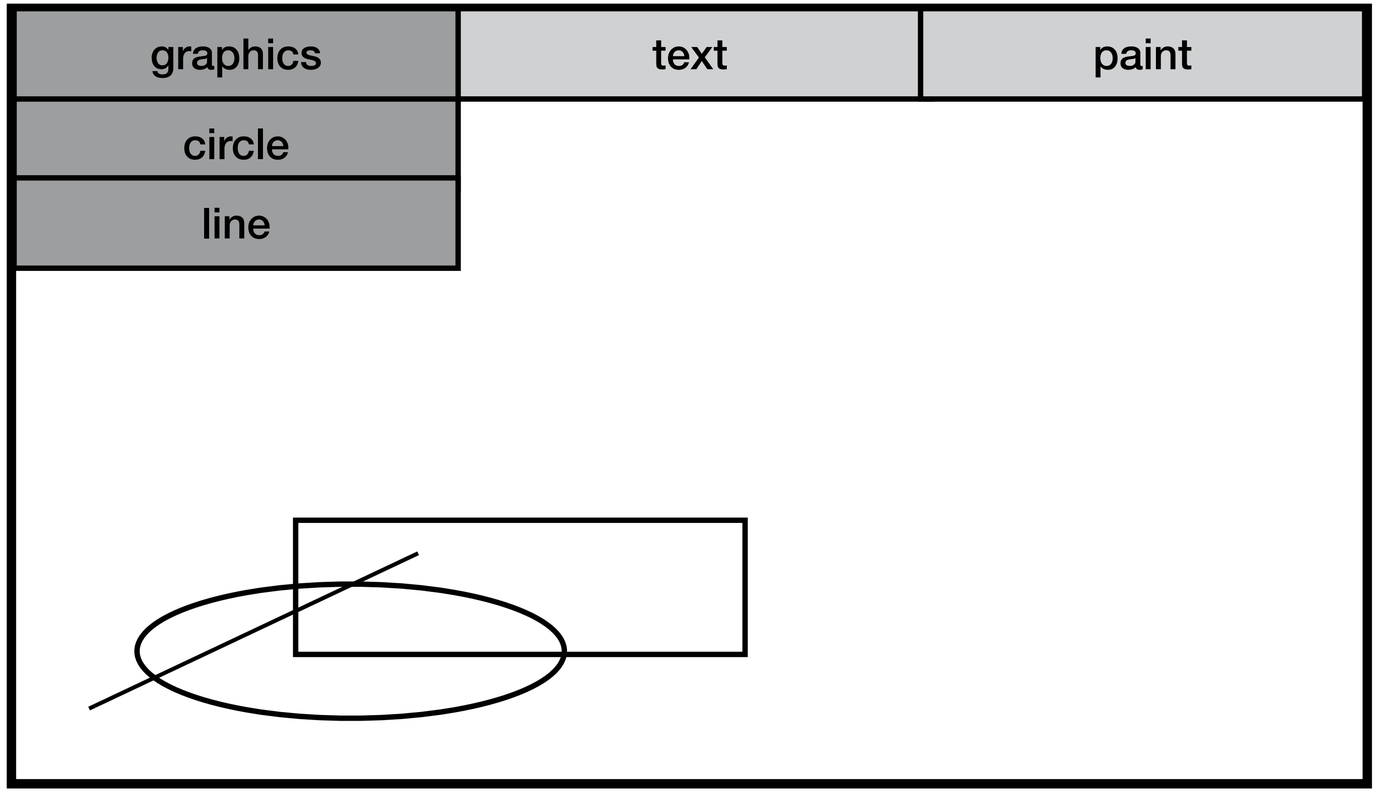
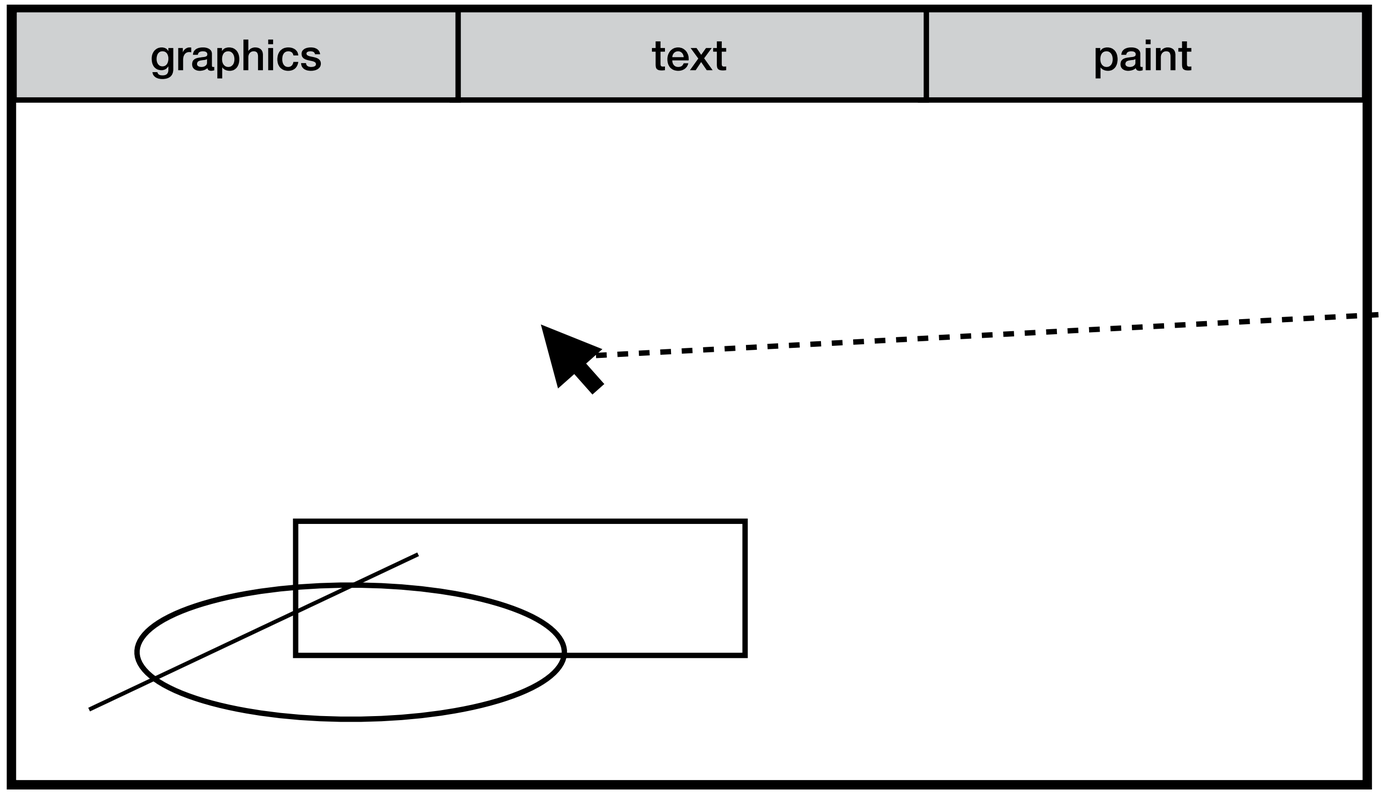


Using STNs in Prototyping

Adapted from “Human–Computer Interaction” by Dix, Finlay, Abowd, and Beale, Chapter 8

Current state: Circle 1



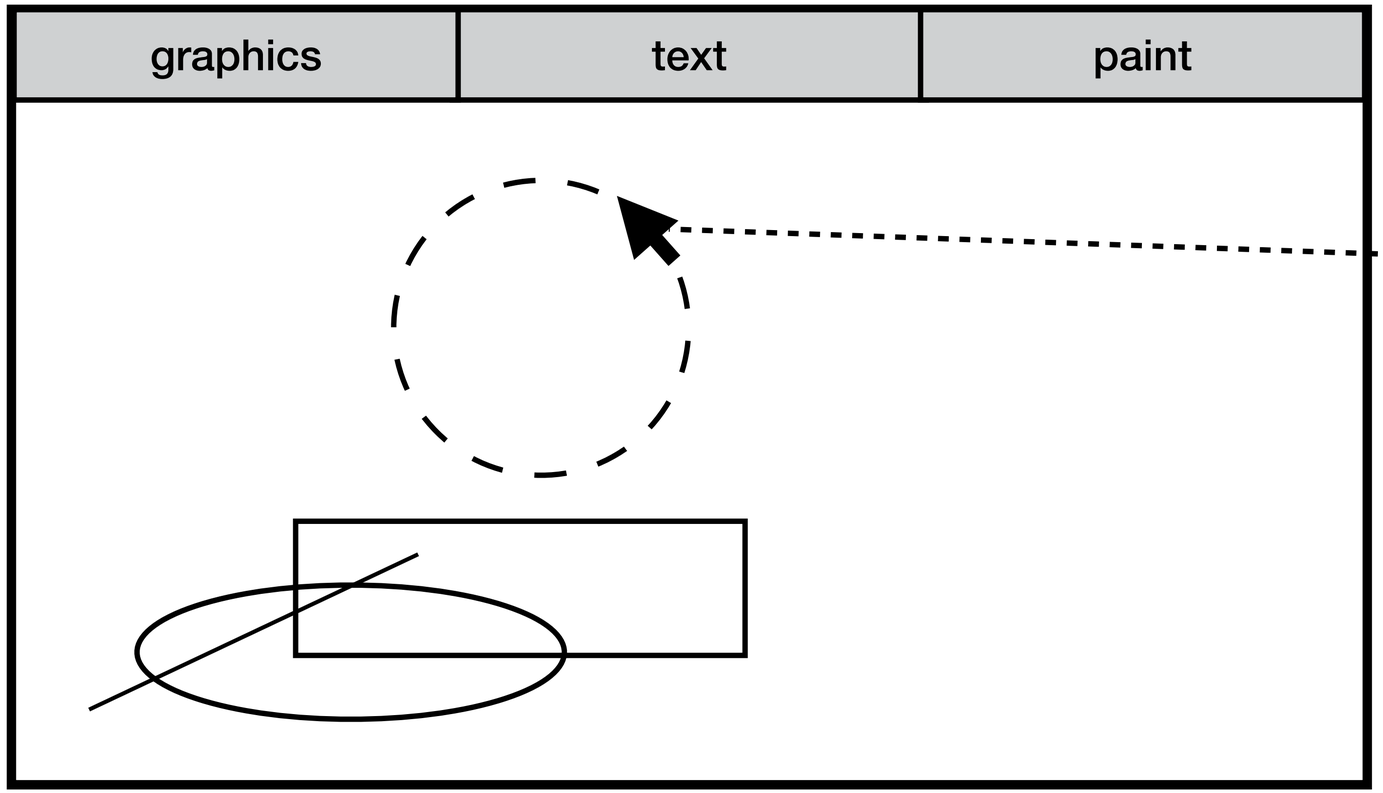
Click this button to simulate a click on the drawing area.

click on centre

Using STNs in Prototyping

Adapted from “Human–Computer Interaction” by Dix, Finlay, Abowd, and Beale, Chapter 8

Current state: Circle 2



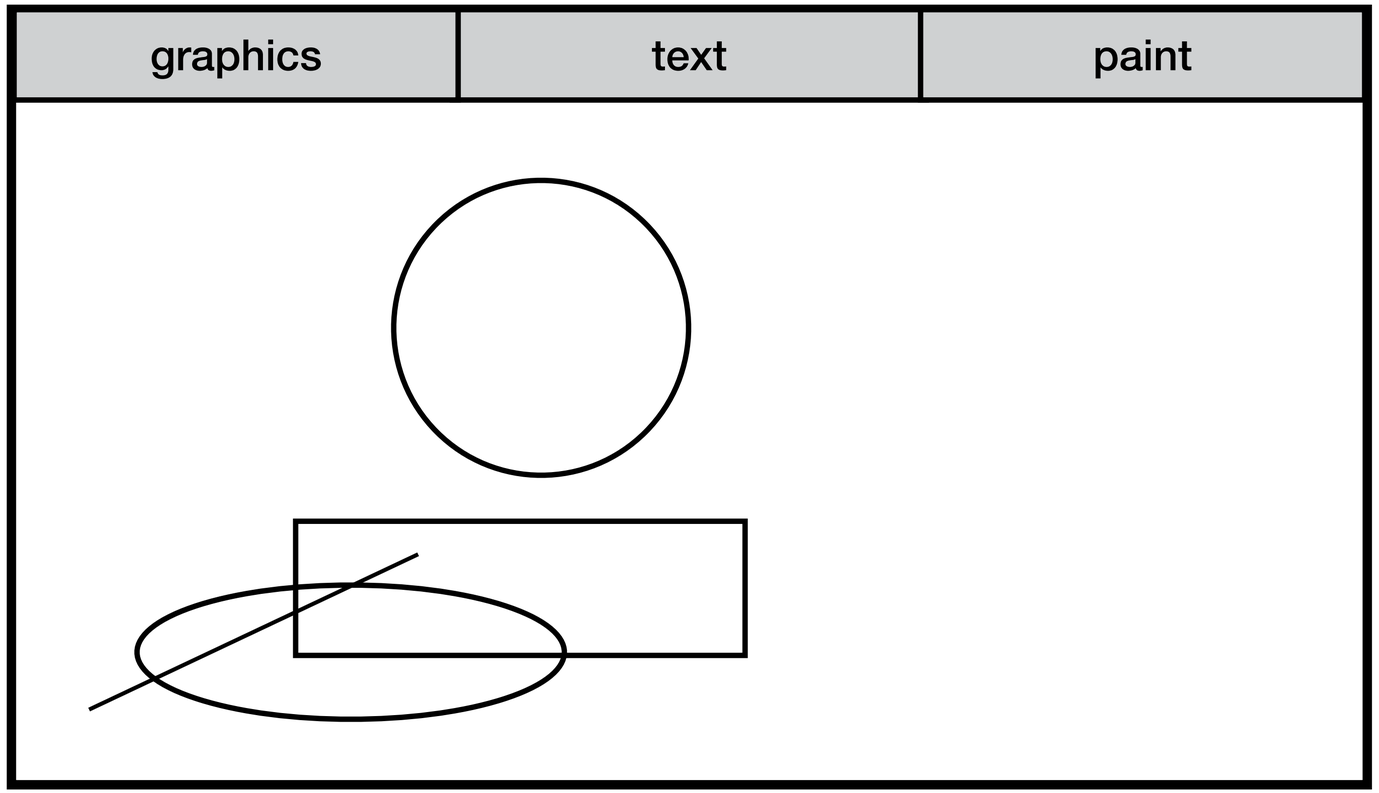
Click this button to simulate a click on the drawing area.

click on circumference

Using STNs in Prototyping

Adapted from “Human–Computer Interaction” by Dix, Finlay, Abowd, and Beale, Chapter 8

Current state: End of drawing



The circle is drawn now.
Click the button to go back to main menu.

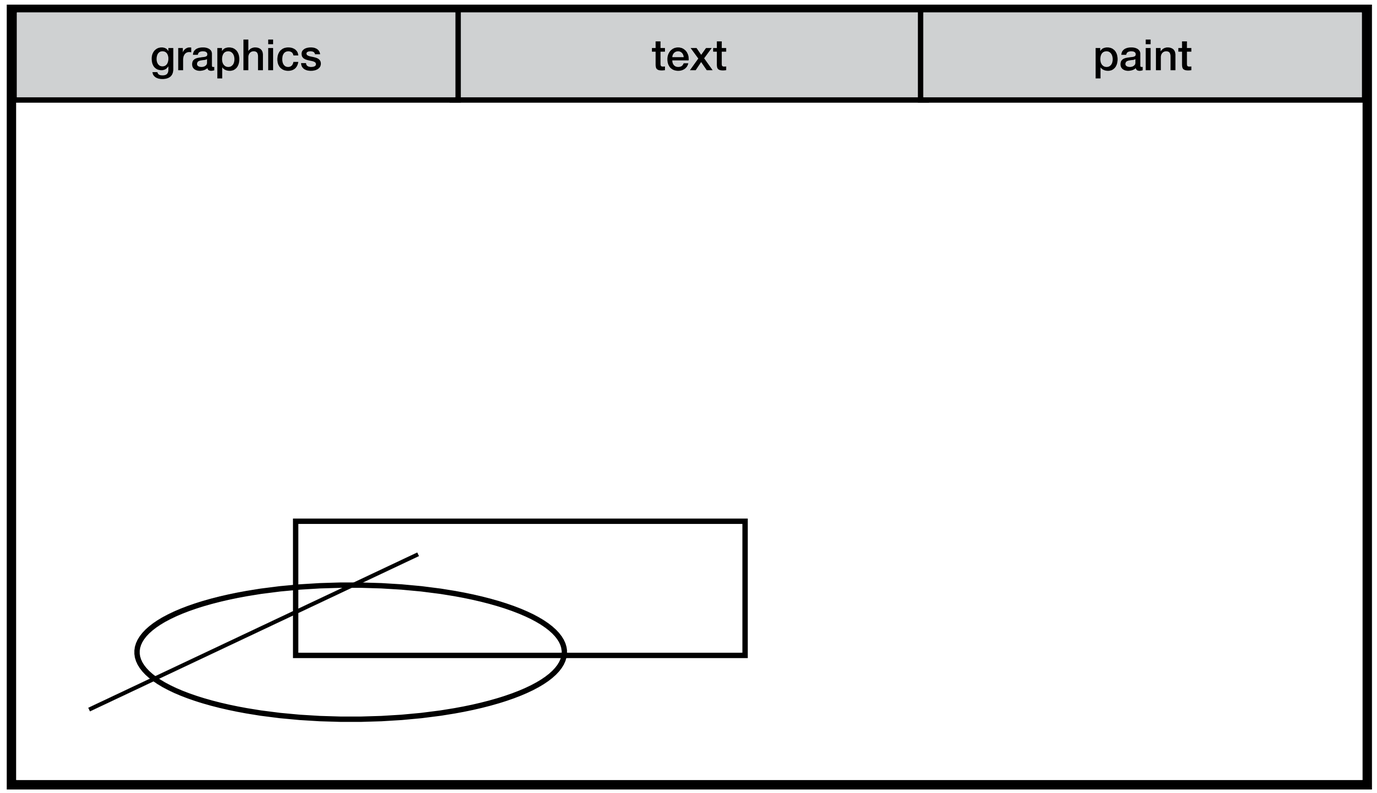
end of sub-state

Using STNs in Prototyping

Adapted from “Human–Computer Interaction” by Dix, Finlay, Abowd, and Beale, Chapter 8

Current state:

- Main Menu
- Circle 1
- Circle 2
- End of drawing



Checking STN Properties: States

Checking STN Properties: States

- Completeness
  - Can you get anywhere from anywhere?
  - Are all possible actions covered in every state?
  - How easily?

Checking STN Properties: States

- Completeness
  - Can you get anywhere from anywhere?
  - Are all possible actions covered in every state?
  - How easily?
- Reversibility
  - Can you get to the previous state?
  - But NOT undo

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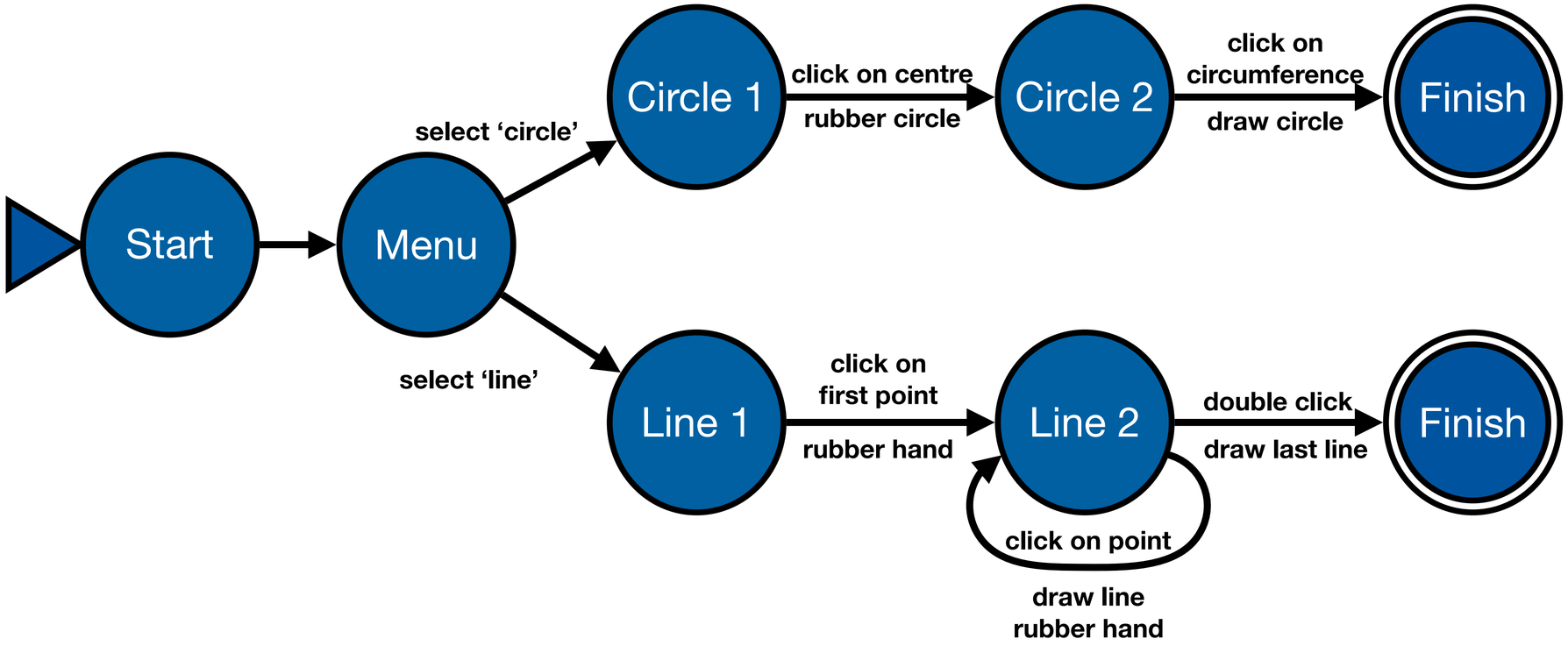
  - But NOT undo
- Dangerous states
  - Some states you don’t want to get to

Checking Transition Properties: Completeness

- Missing arcs indicate unspecified user input
  - What happens when the user double-clicks in the circle states?



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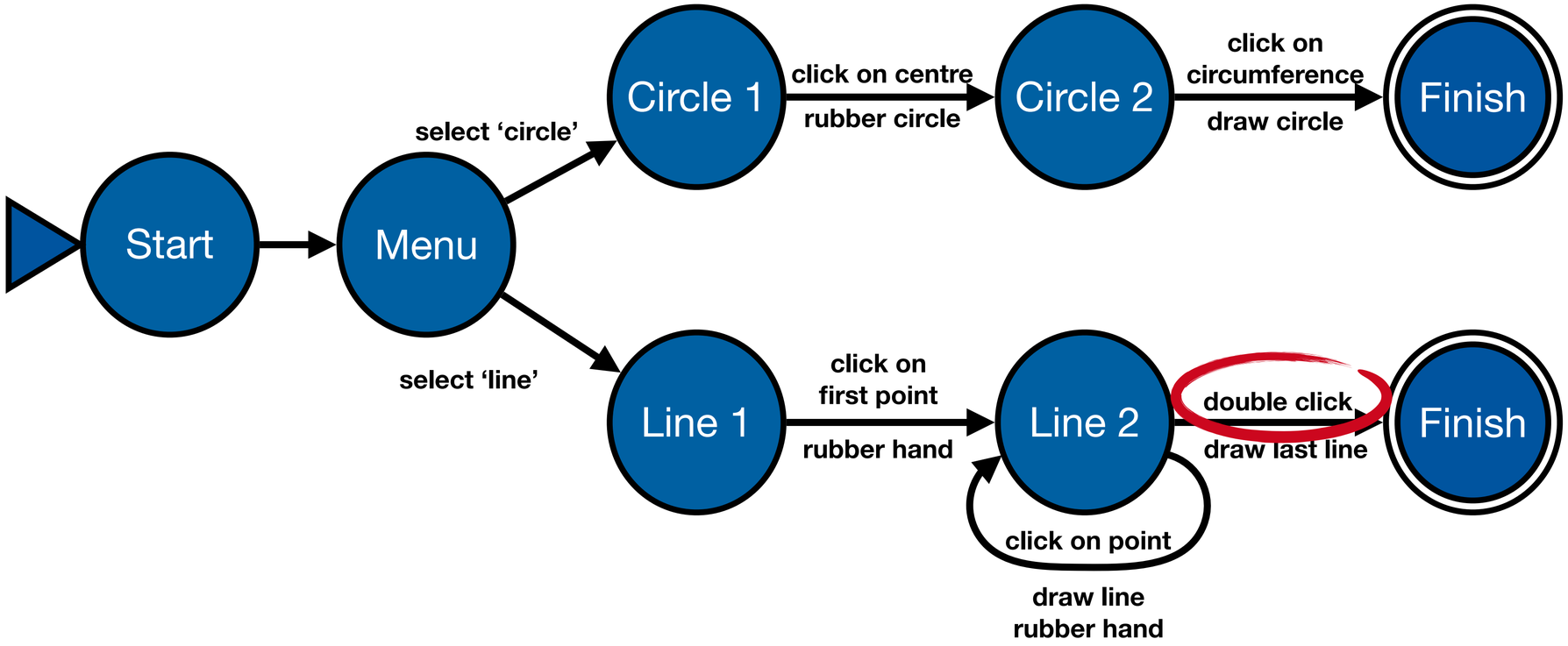

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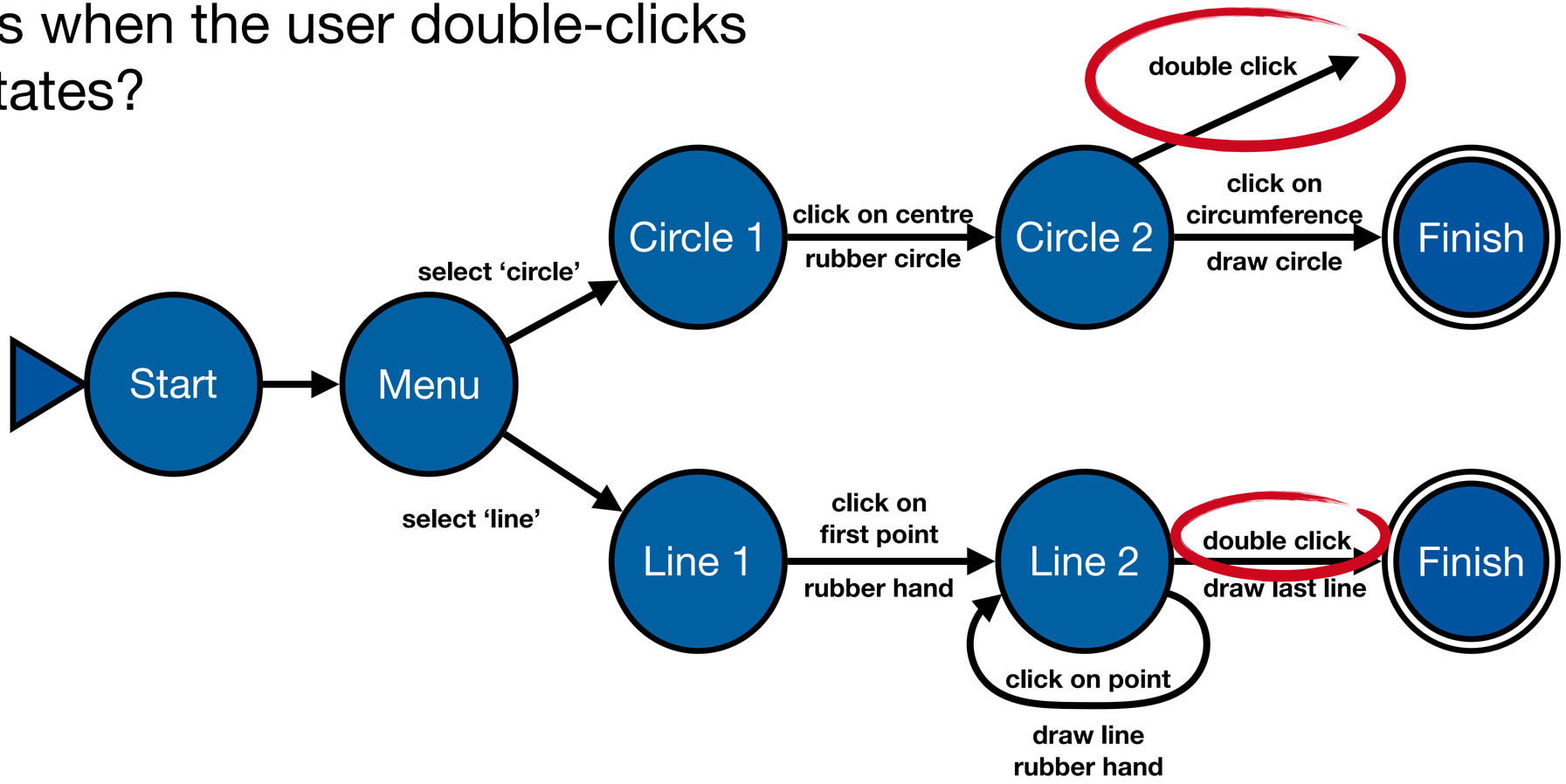

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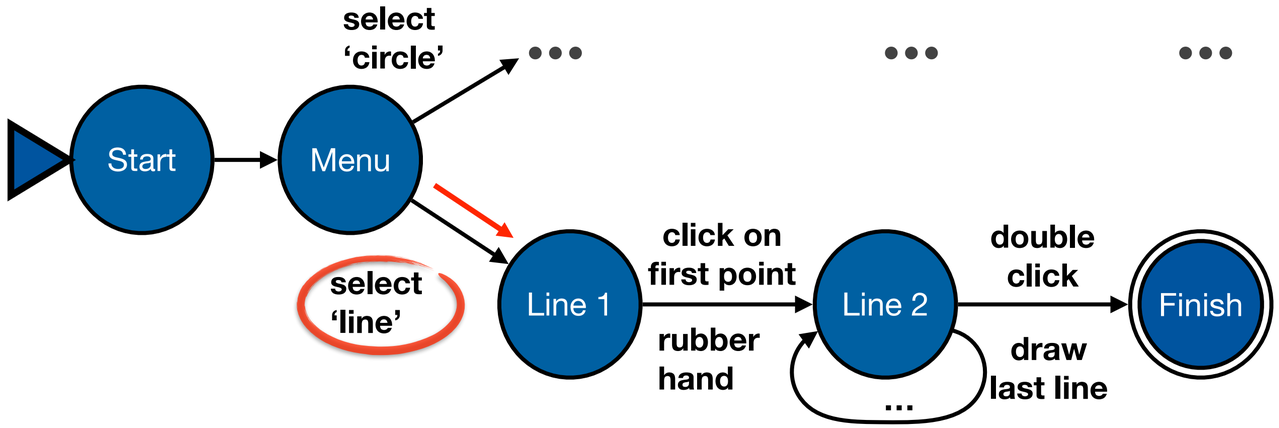

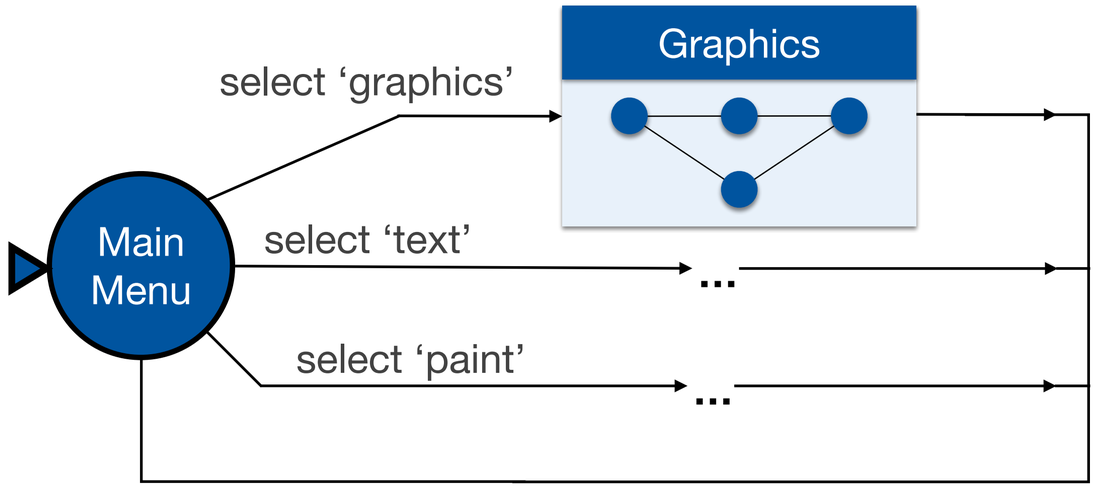

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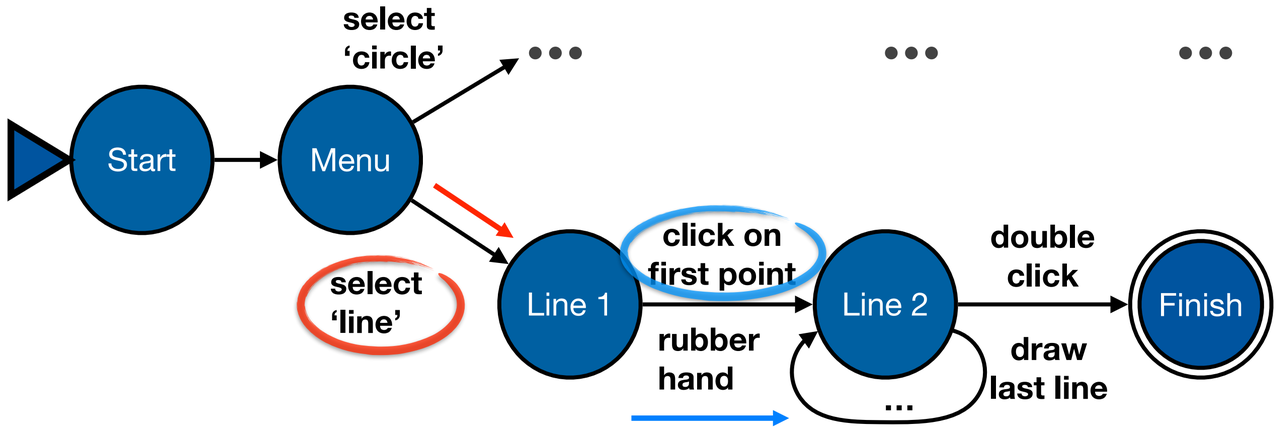

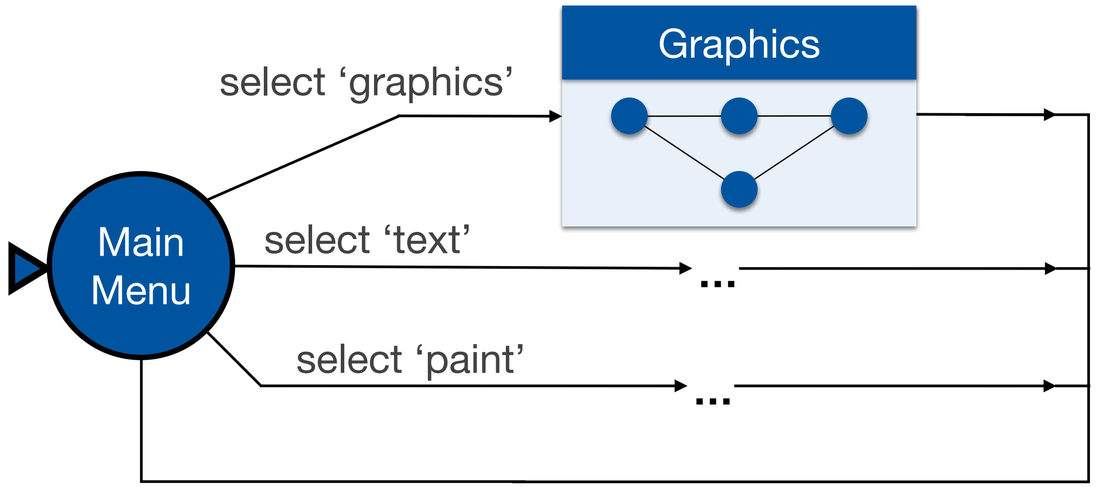

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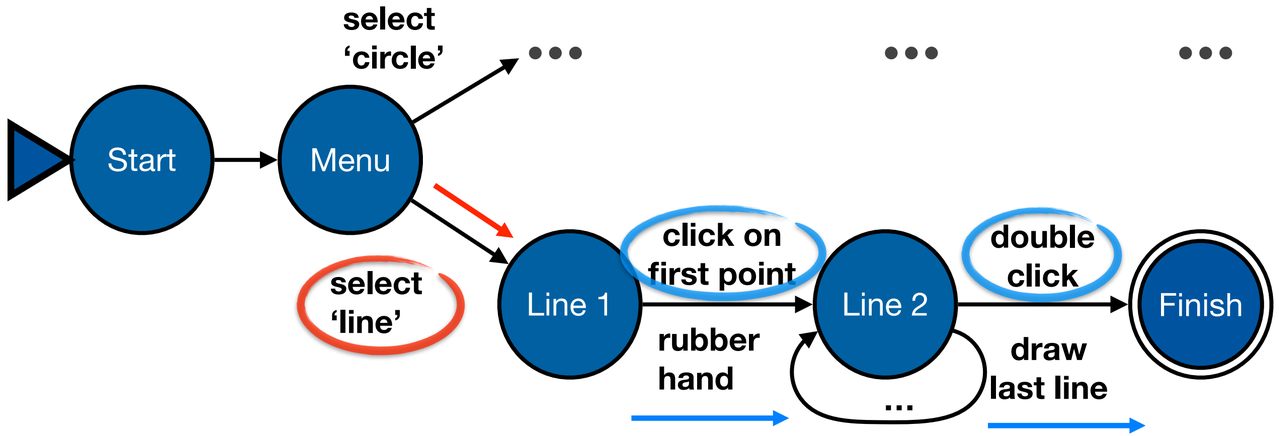

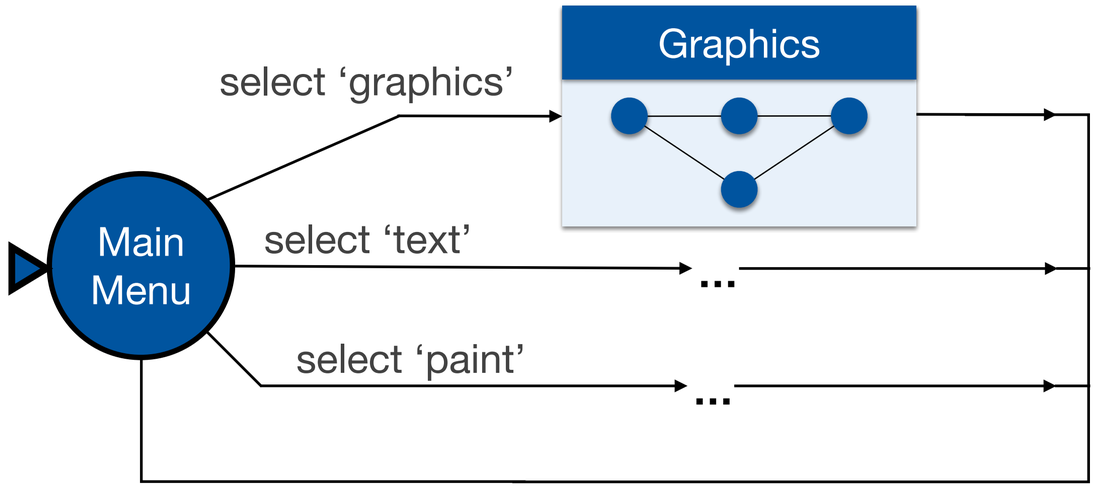

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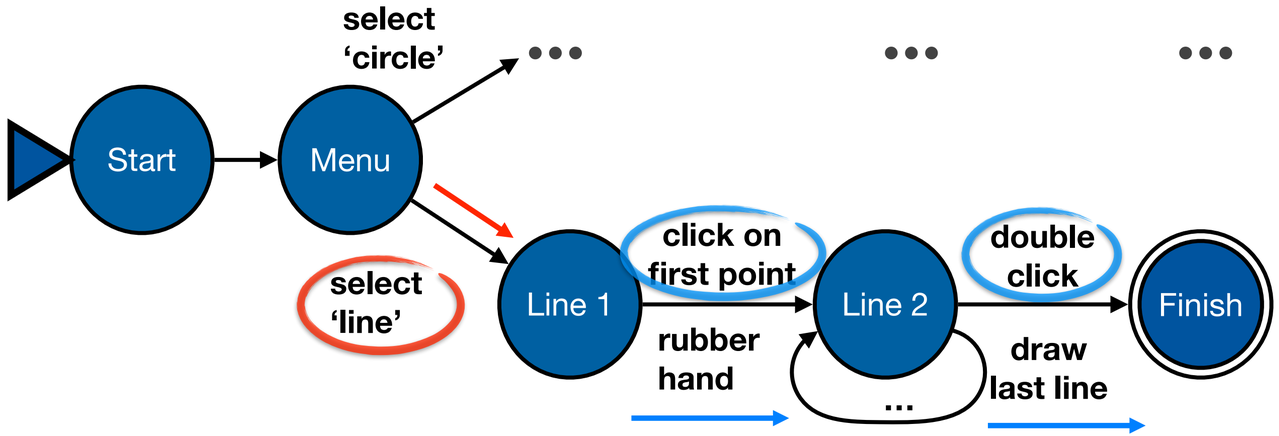

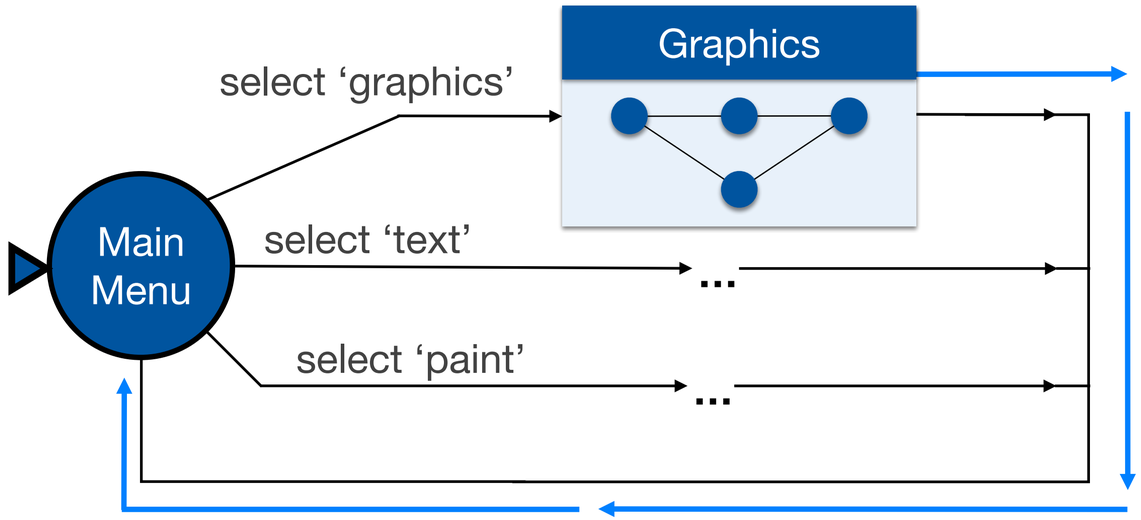

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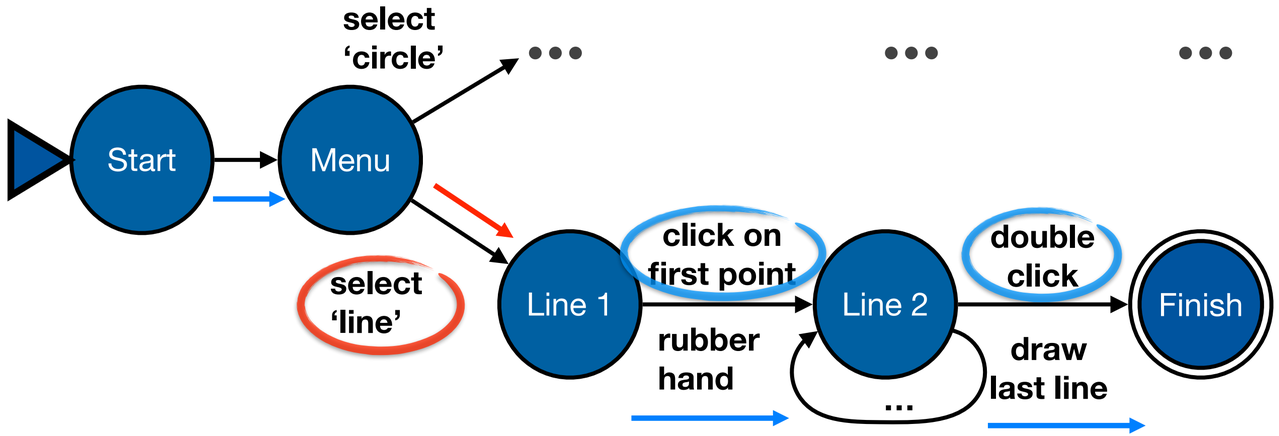
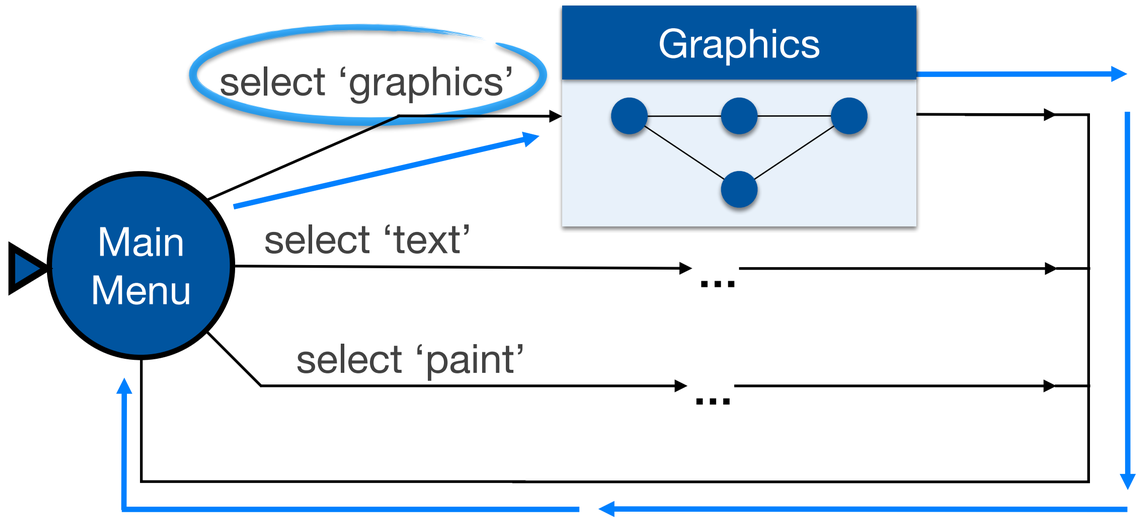
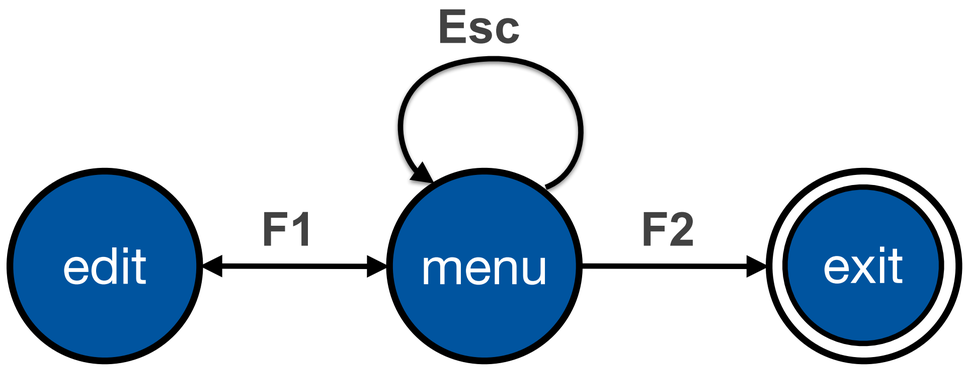




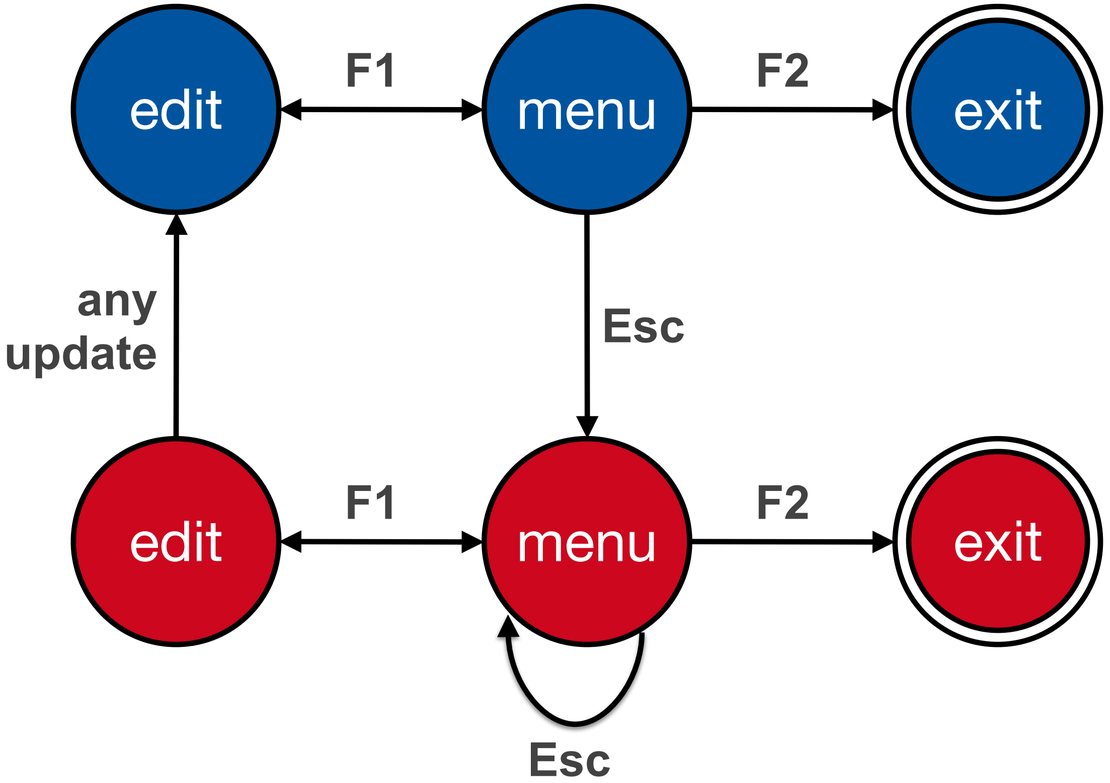
Dangerous States Example

- Word processor: two modes and exit
  - F1 - changes mode
  - F2 - exit (and save)
  - Esc - no mode change
- But ... Esc resets autosave



Dangerous States Example

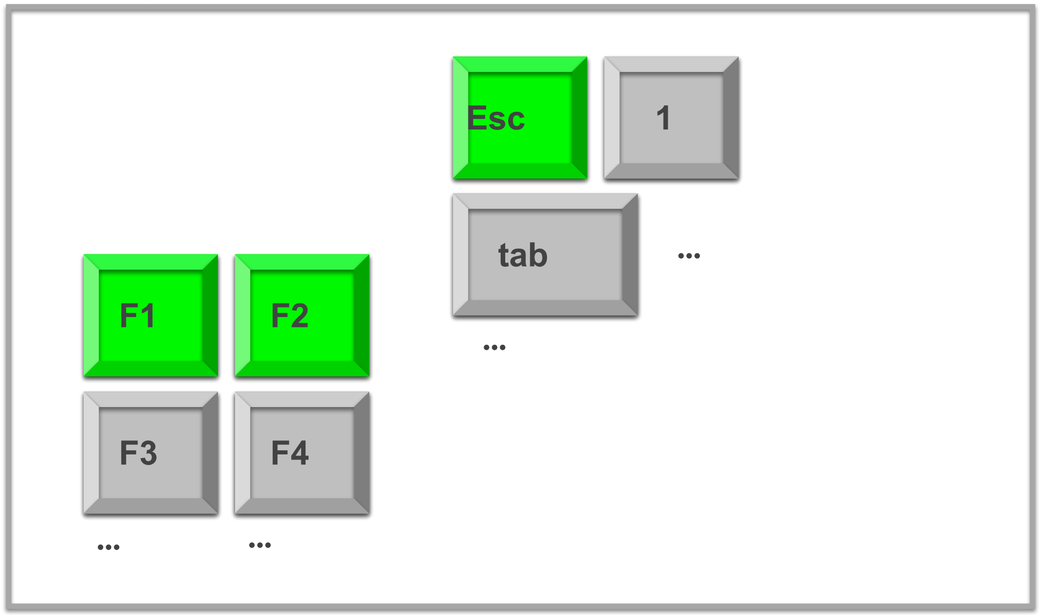
- Exit with/without save ⇒ dangerous states
- Duplicate states - semantic distinction

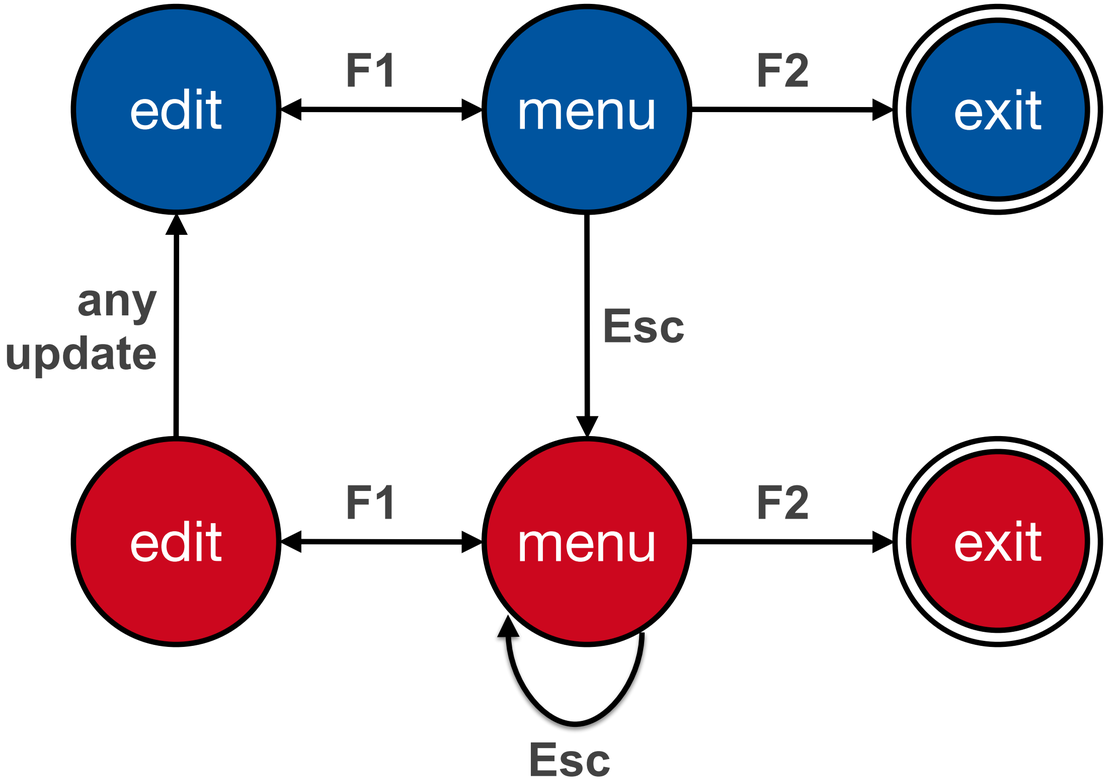


- F1-F2 - exit with save
- F1-Esc-F2 - exit with no save

Dangerous States Example: Layout Matters

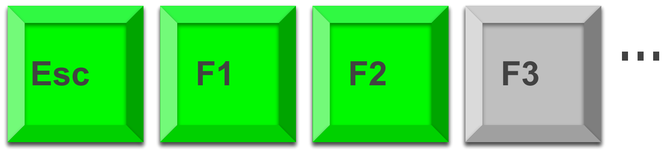
old keyboard - OK





Dangerous States Example: Layout Matters

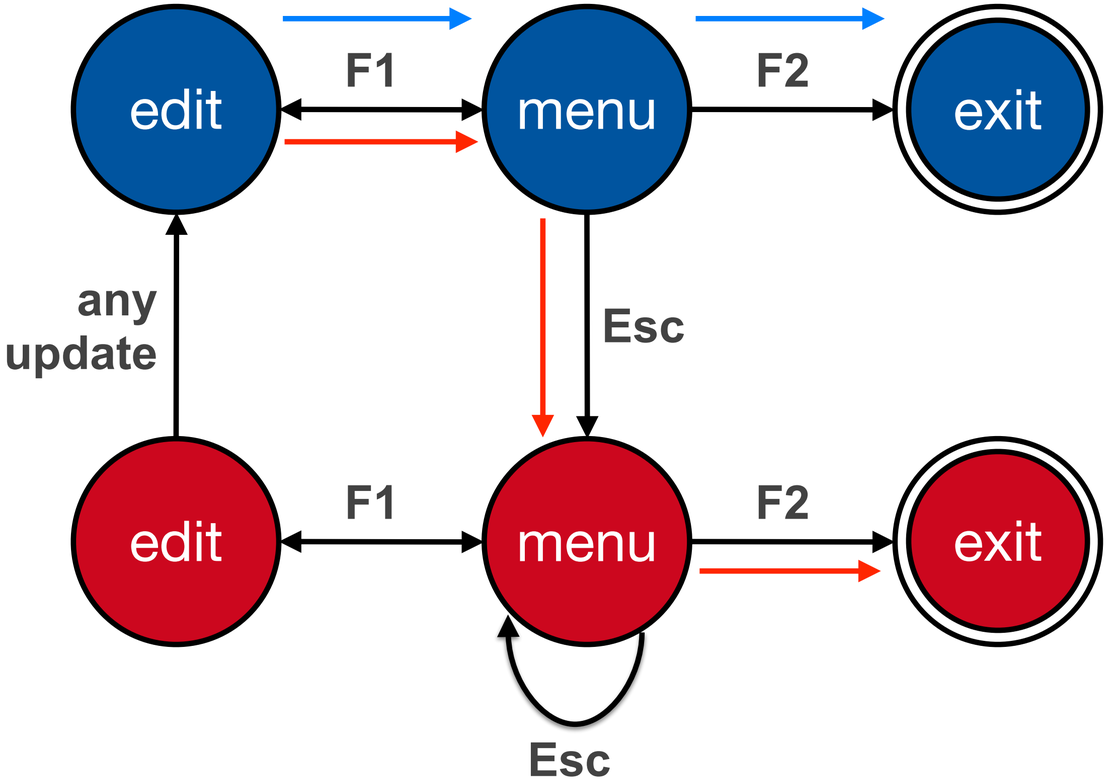
new keyboard layout



Intend F1-F2 (save)

Finger catches Esc

F1-Esc-F2 - disaster!



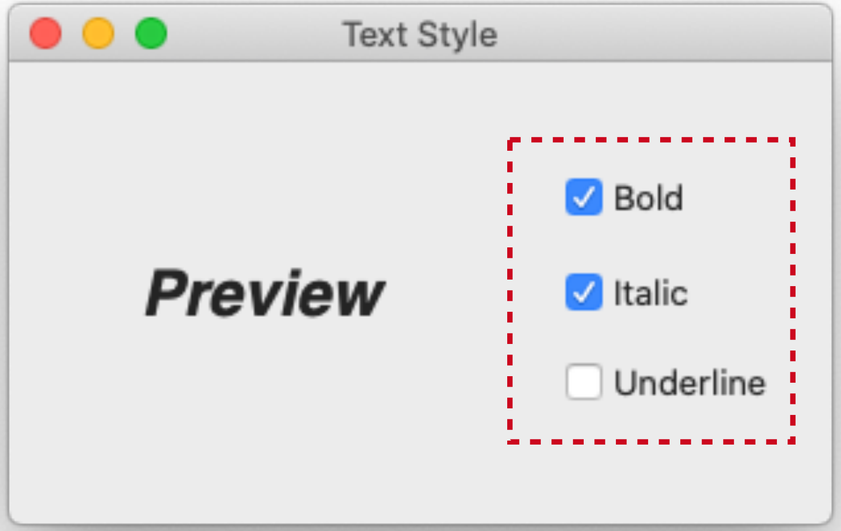
Checking STN Properties: Other Transition Properties

- Determinism
  - Several arcs for one action
    - Deliberate: application decides
    - Accidental: production rules
- Nested escapes
- Consistency
  - Same action, same effect?
  - Modes and visibility

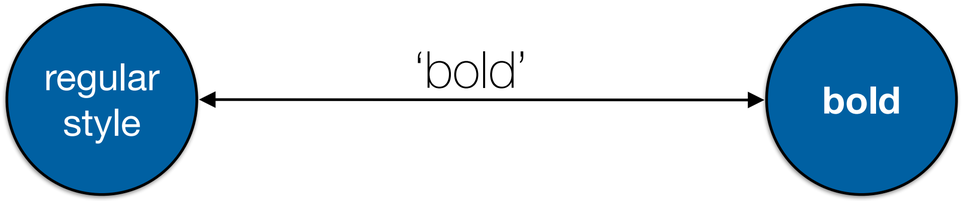
In-Class Exercise: STN

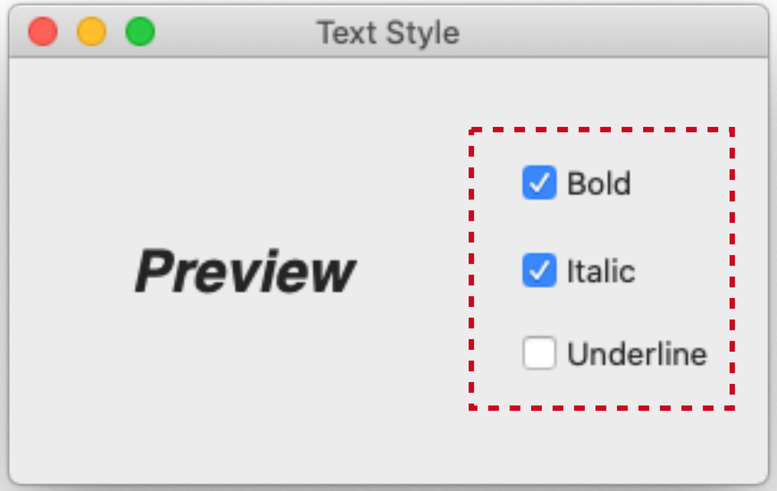
- Simple dialog to select bold, italics, and/or underline

- Draw the state diagram for:
  - Only Bold checkbox
  - Bold and italics checkboxes
  - All three checkboxes

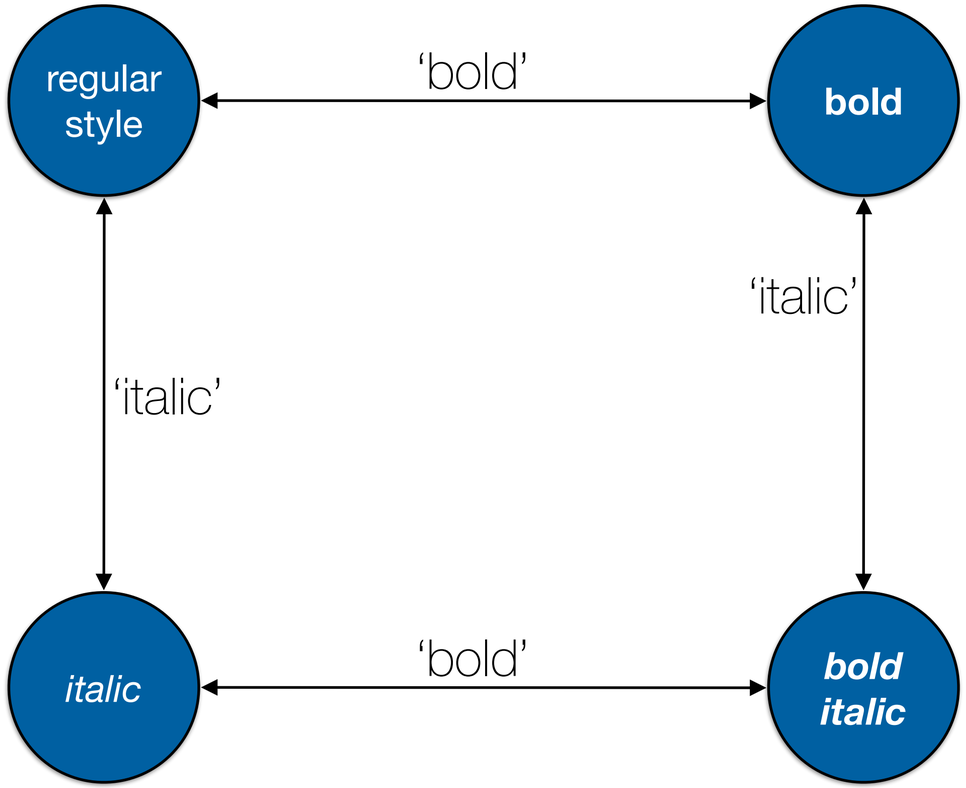


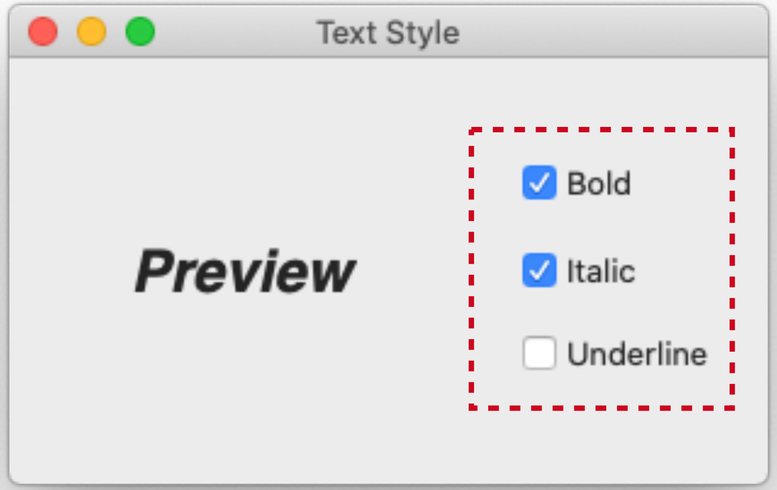
Bold Checkbox



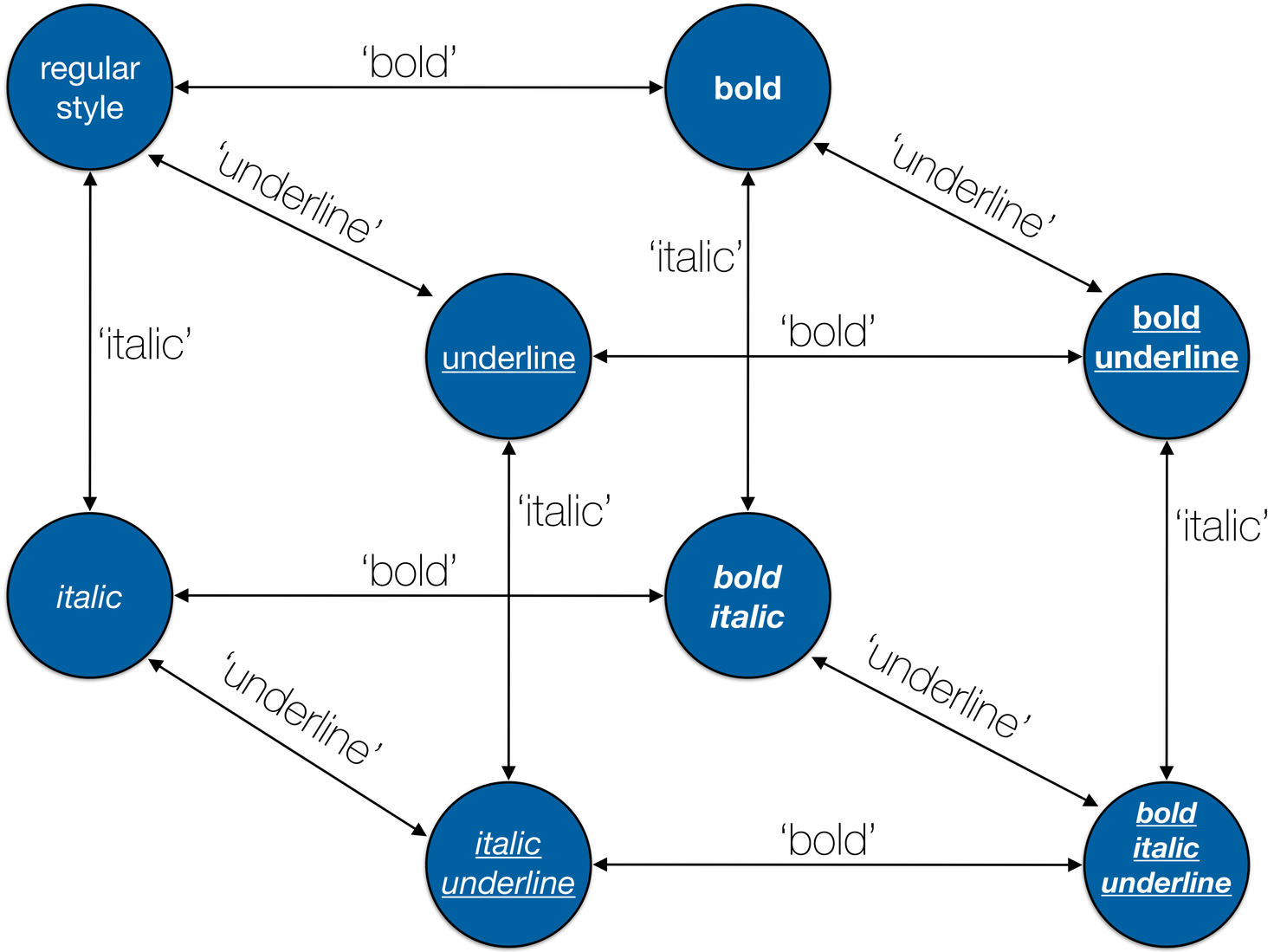


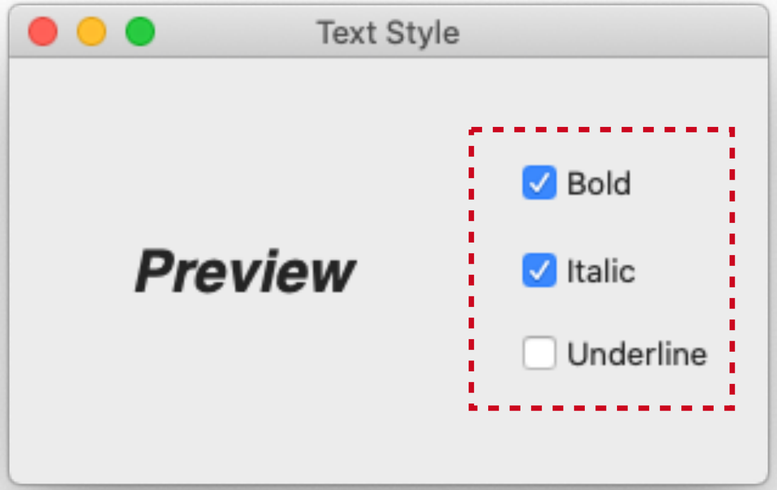
Bold & Italic Combined



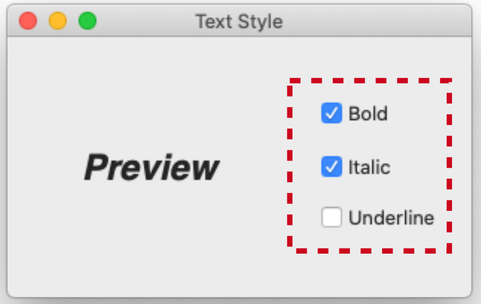


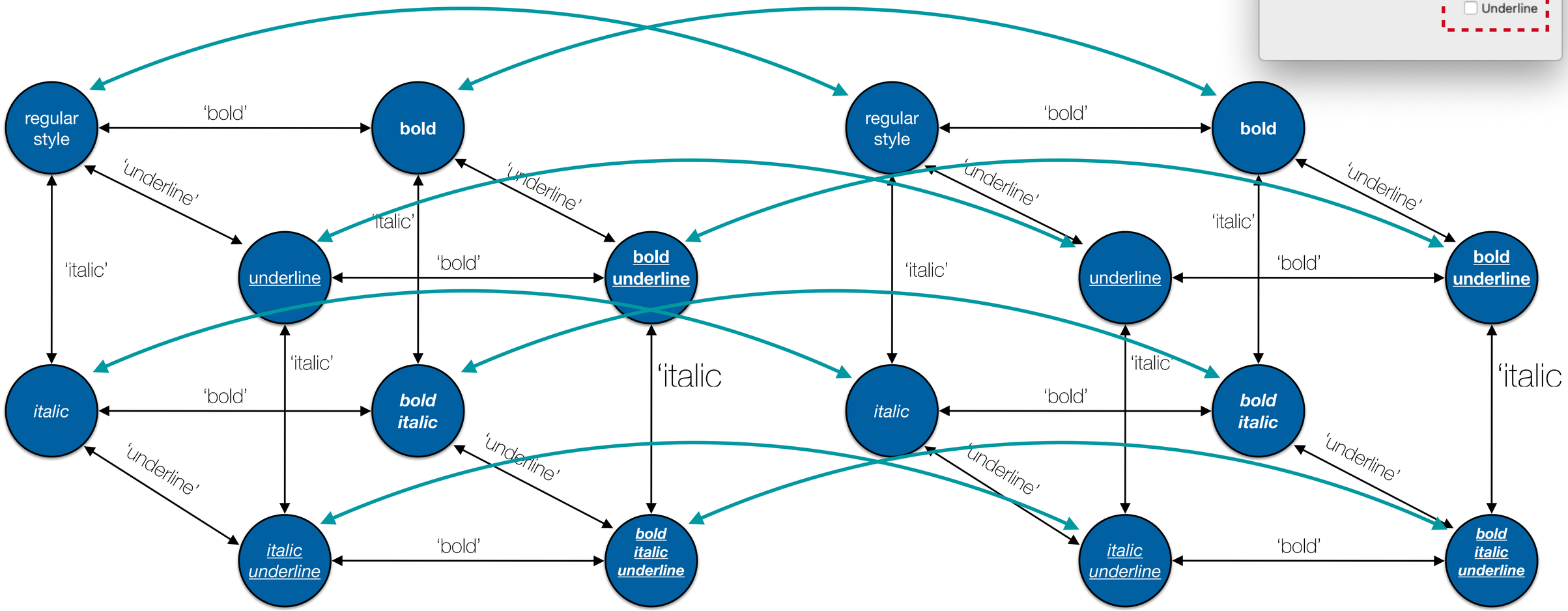
All Three Options





Adding Another Option…

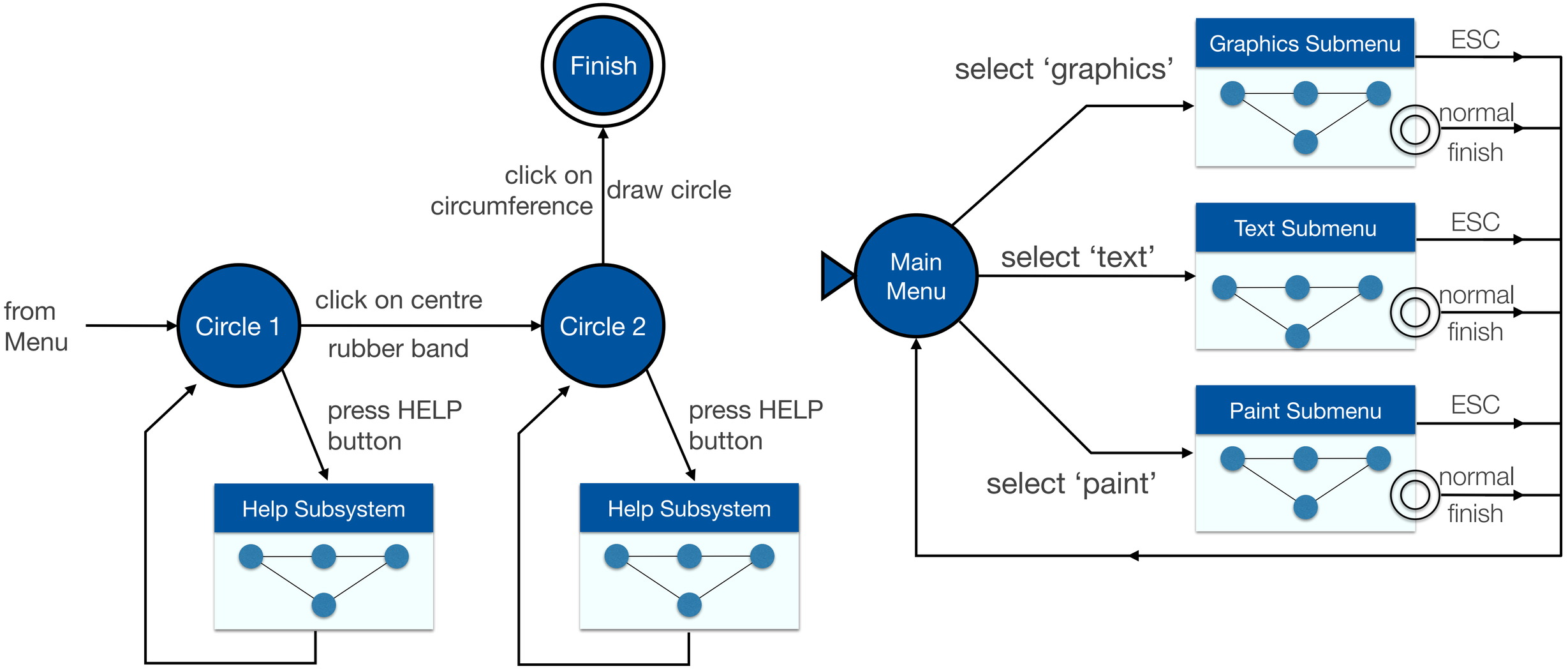




STNs: State Explosion

- Problem: Combining two concurrent STNs with N and M states leads to new STN with N × M states
- STN hides clear structure of the dialog
- Especially problematic with modern GUIs
- Similar problems with “Escape” and “Help” options
  - ESC can be modeled as special second “Finish” exit active throughout subdialog
  - Help can be modeled as little subdialog hanging off every single state in the STN
  - Gets messy

Example: ESC & Help in STNs

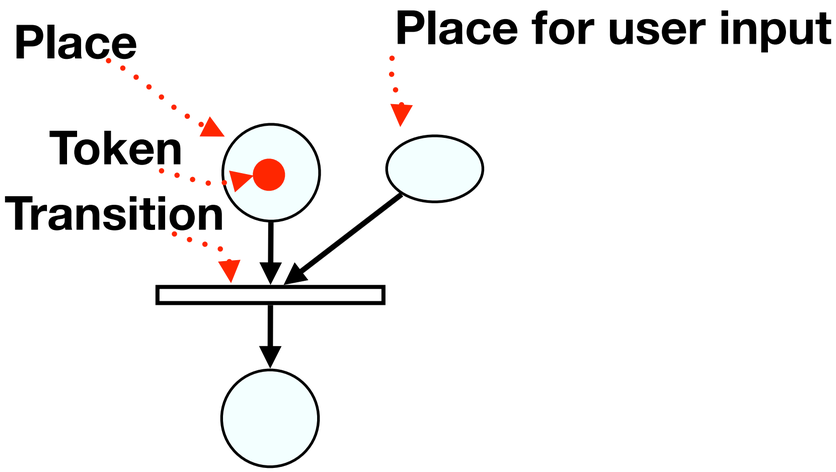


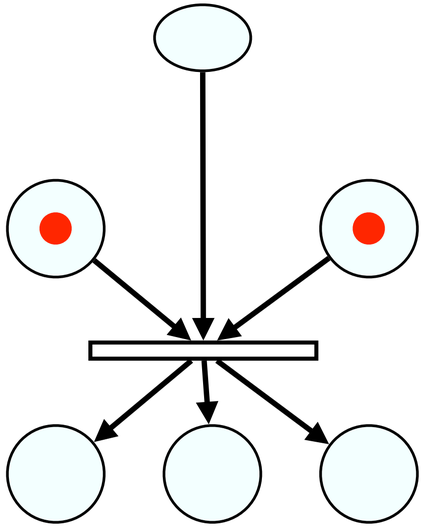
Petri Nets

- Better approach to dialogs that have several states at once
- But not better for sequential dialogs and mutually exclusive UI elements (radio buttons)
- Relatively old formalism to model concurrency

Petri Nets

- Transition fires when all input places have one or more token
  - A token is produced in each output place
- Positions of all tokens represent the current state
  - NOTE: This is different from state machines





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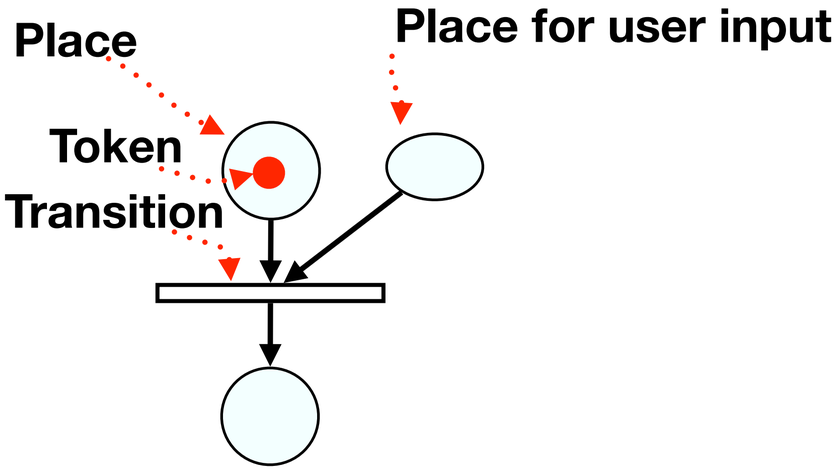

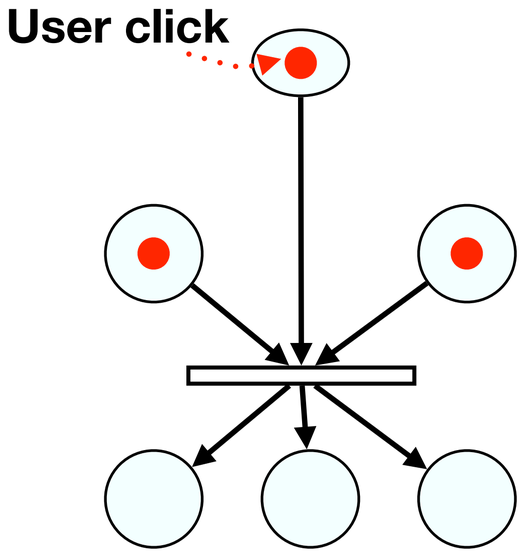

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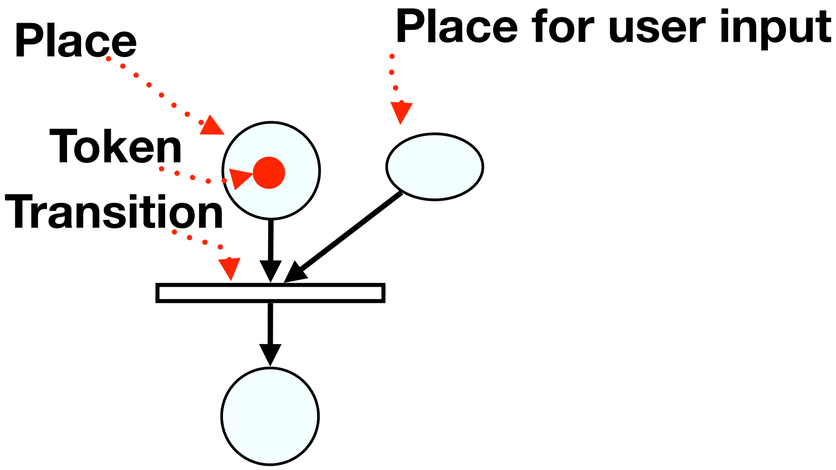

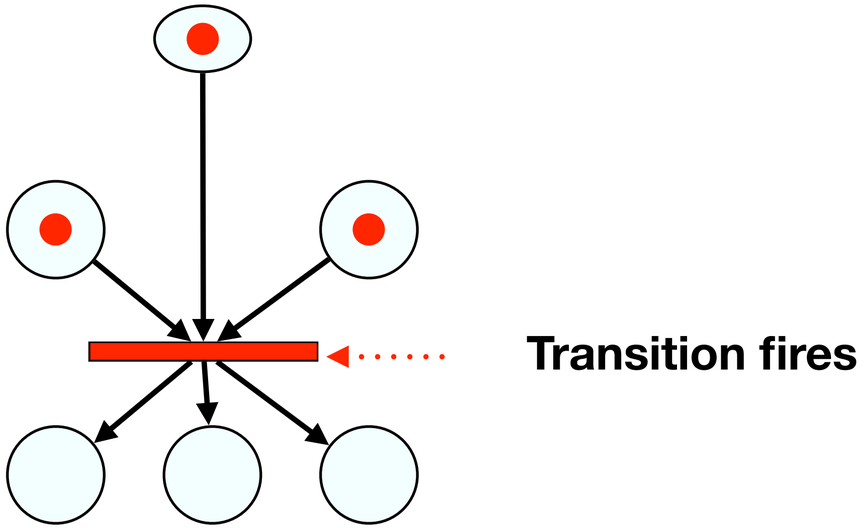

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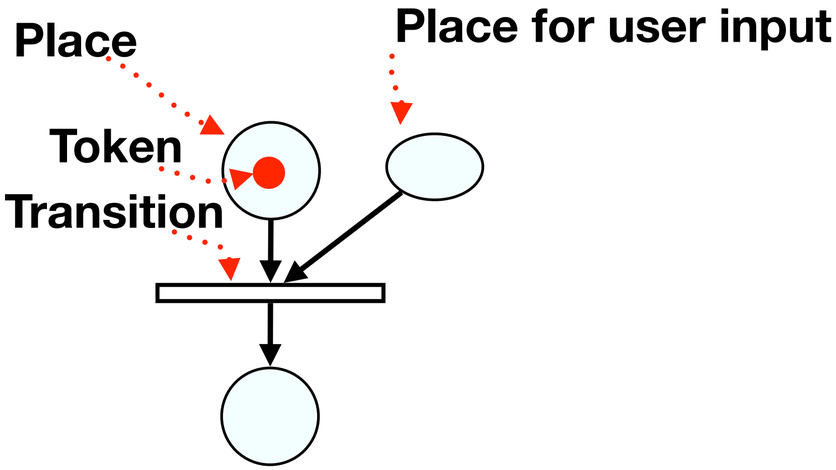

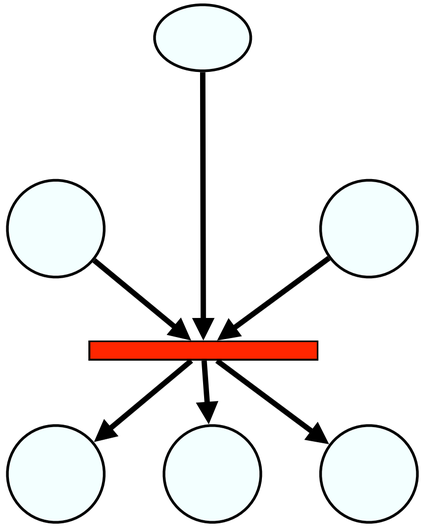

Tokens disappear from input places

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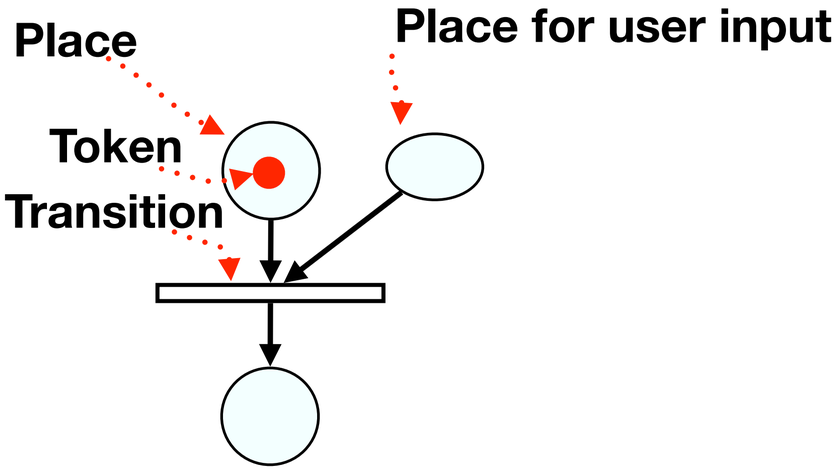
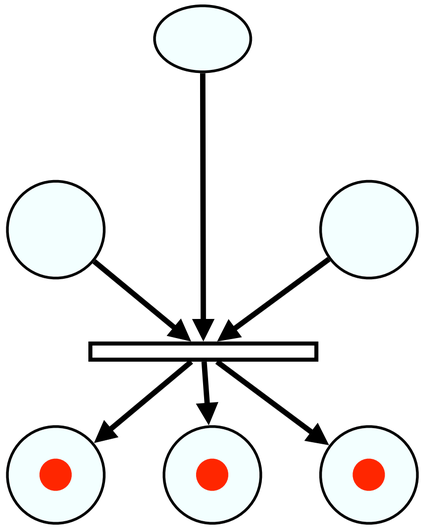
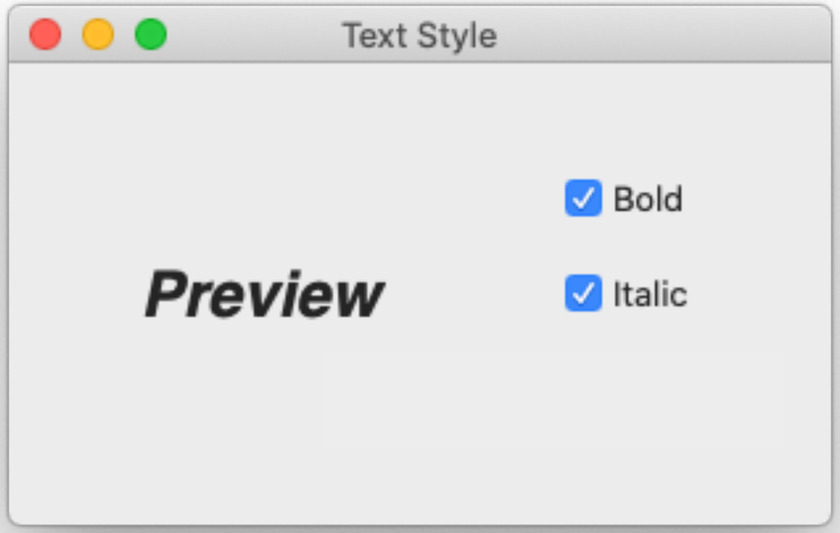




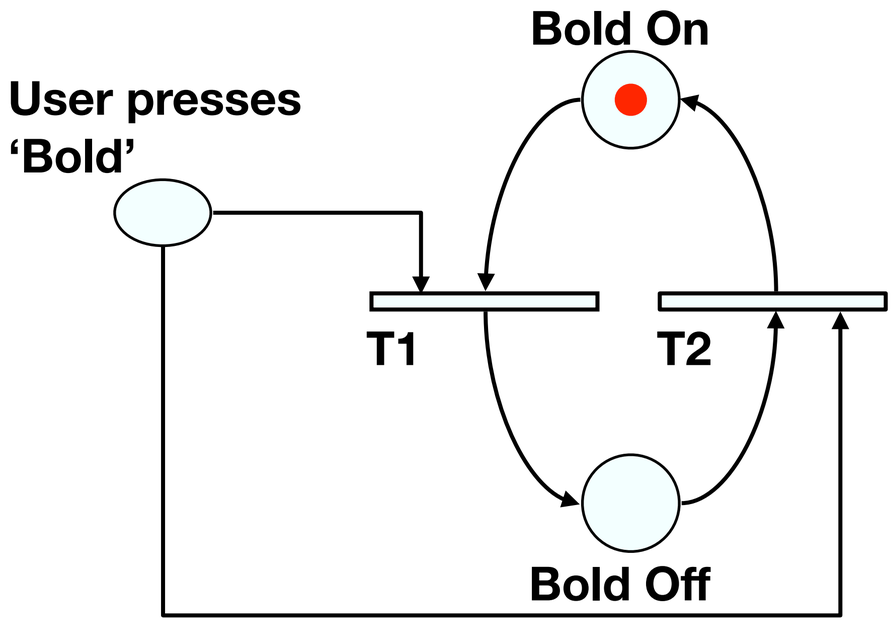
Tokens appear in output places

In-Class Exercise

Draw the Petri net for our dialog box with concurrent “Bold” and “Italic” options (ignore “Underline” for now)



Petri Net For “Bold & Italic” Dialog



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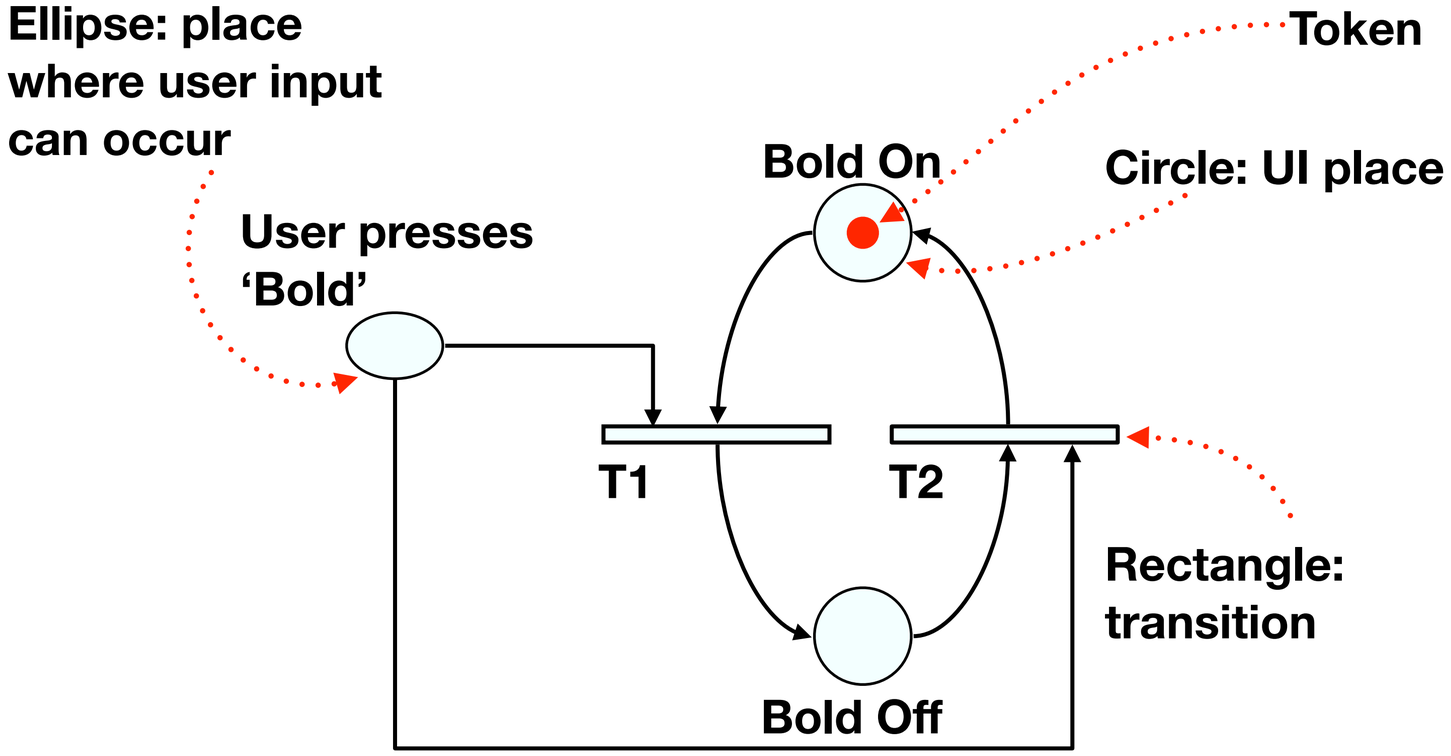

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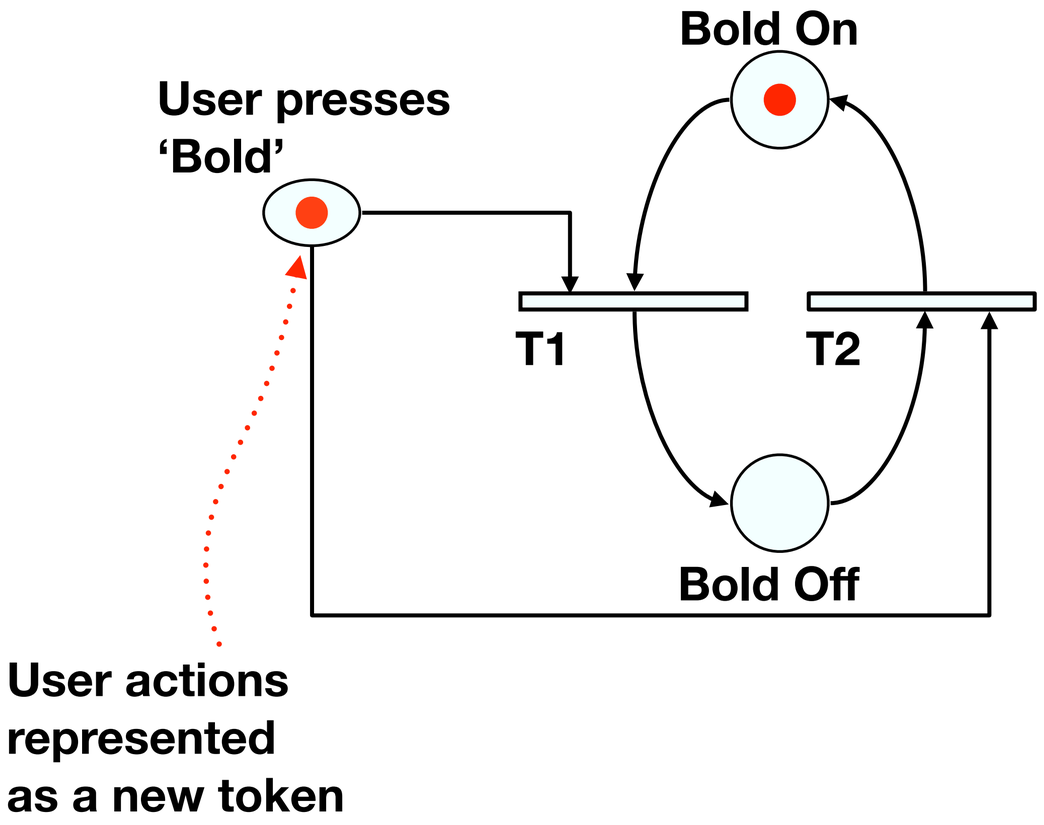

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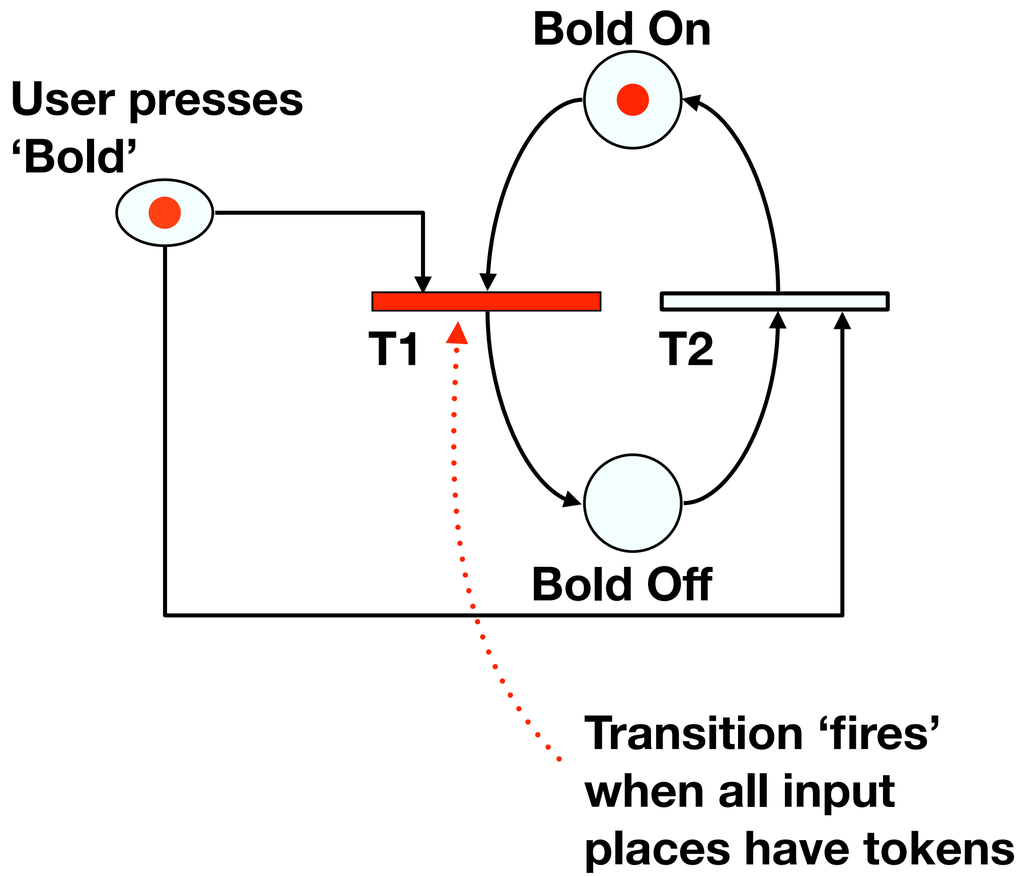

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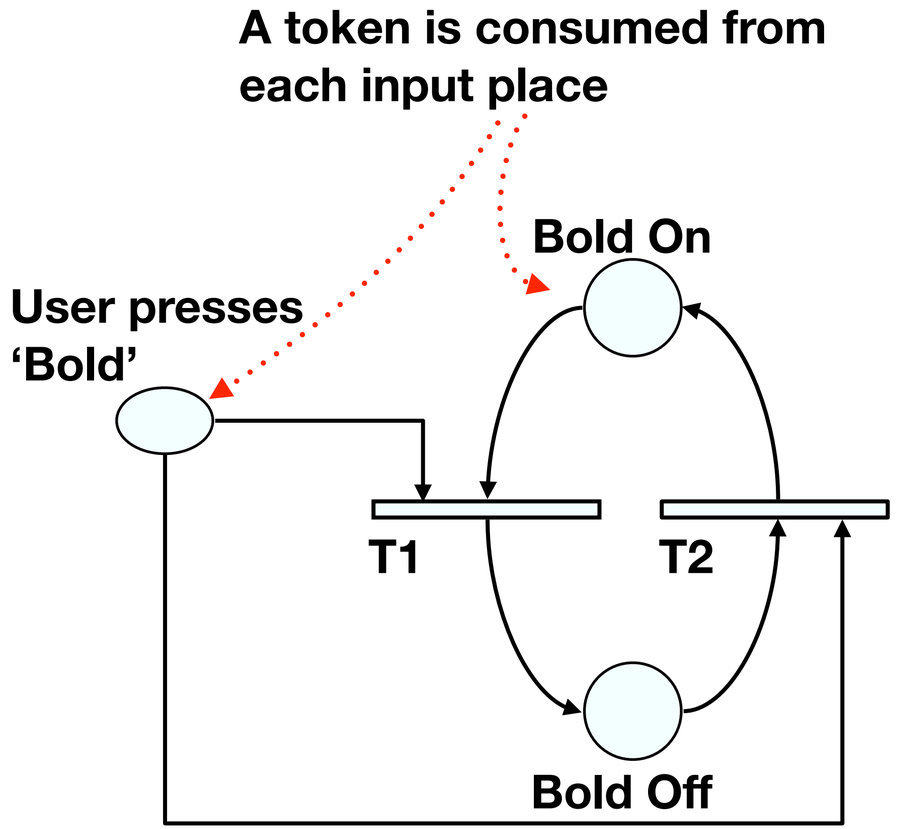

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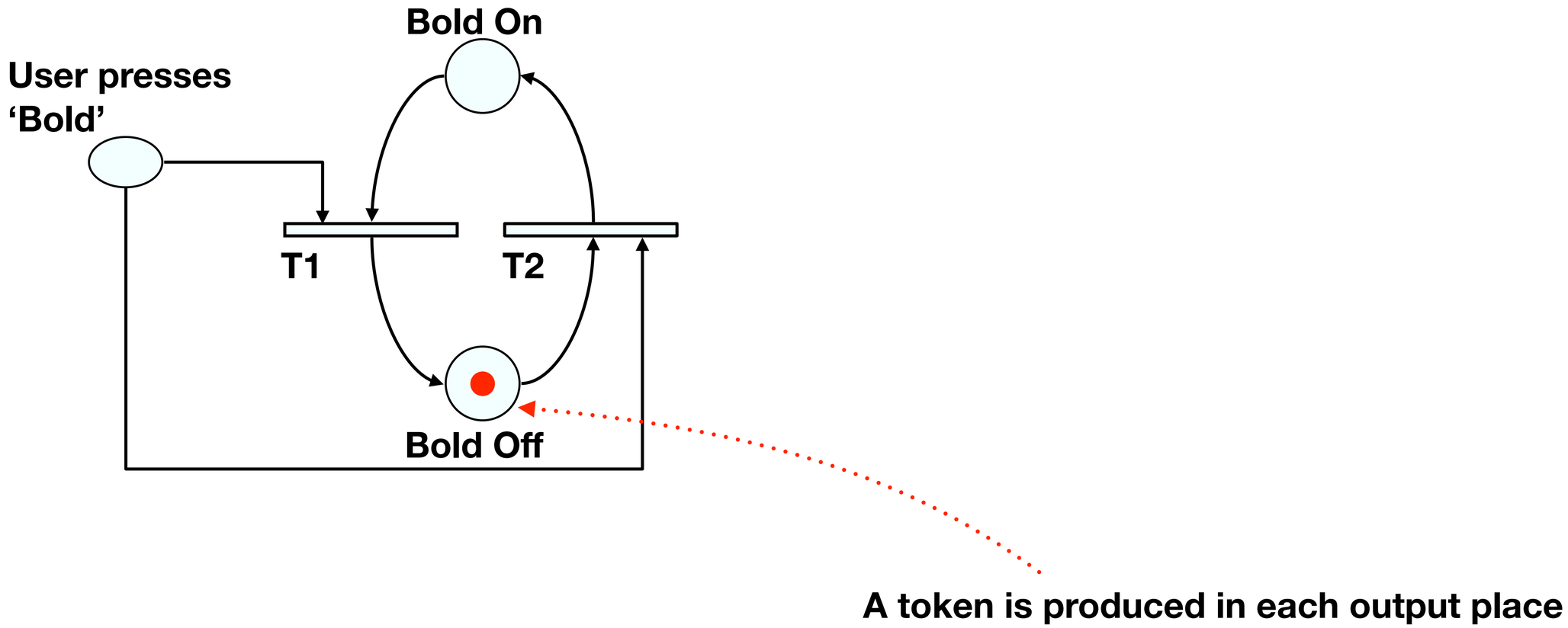

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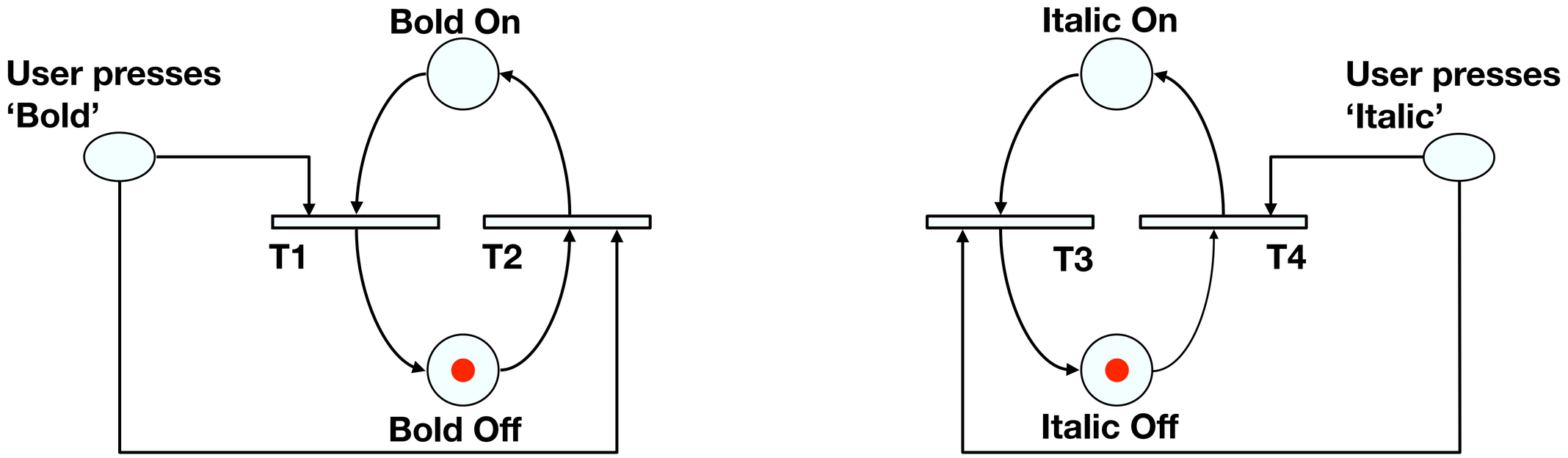
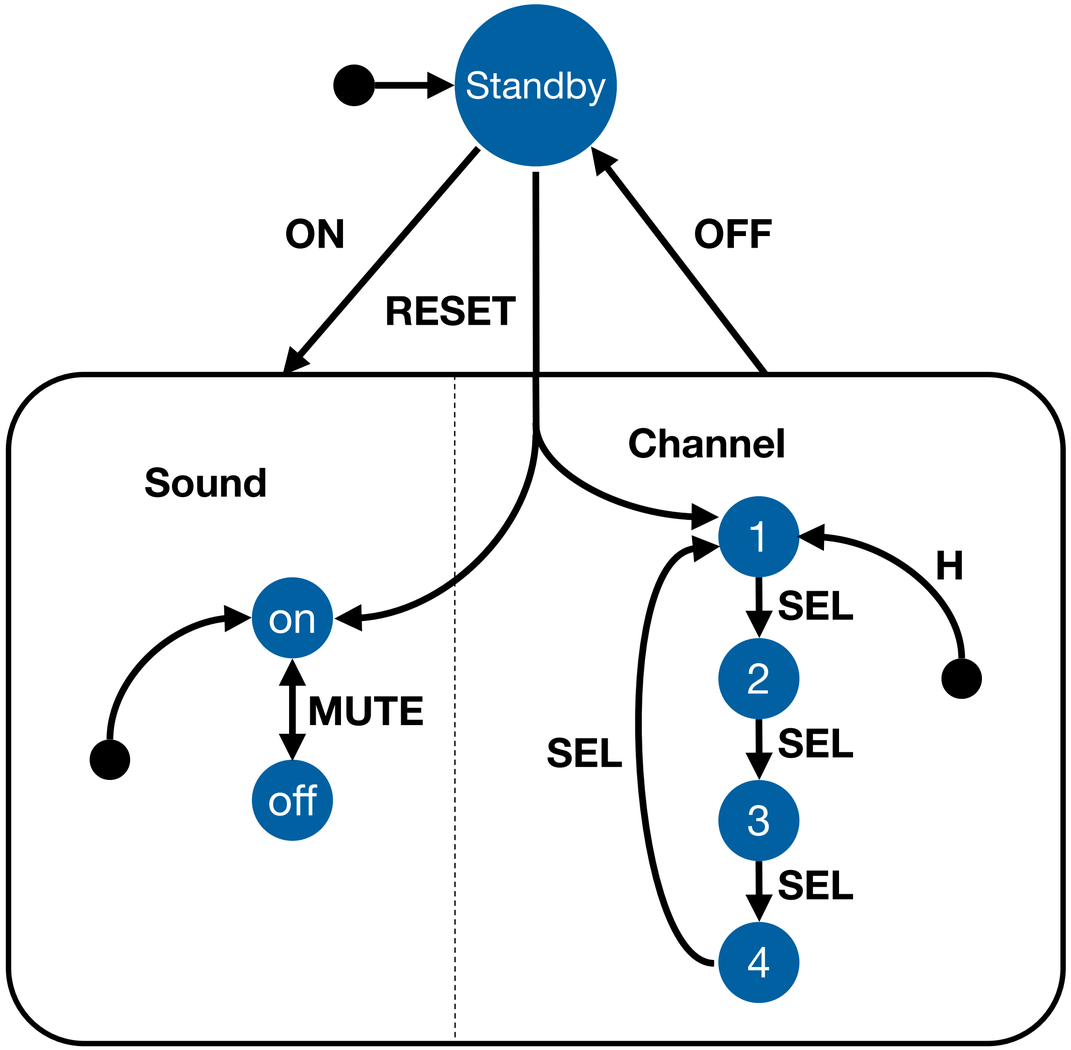


State Charts

- By Harel; used in UML
- Example: TV Control Panel
- State Charts extend STNs
  - Hierarchy
  - Concurrent sub-nets
    - ON resumes both state machines
  - Escapes
    - OFF always active
  - History
    - Link marked “H” goes back to last state on re-entering subdialog



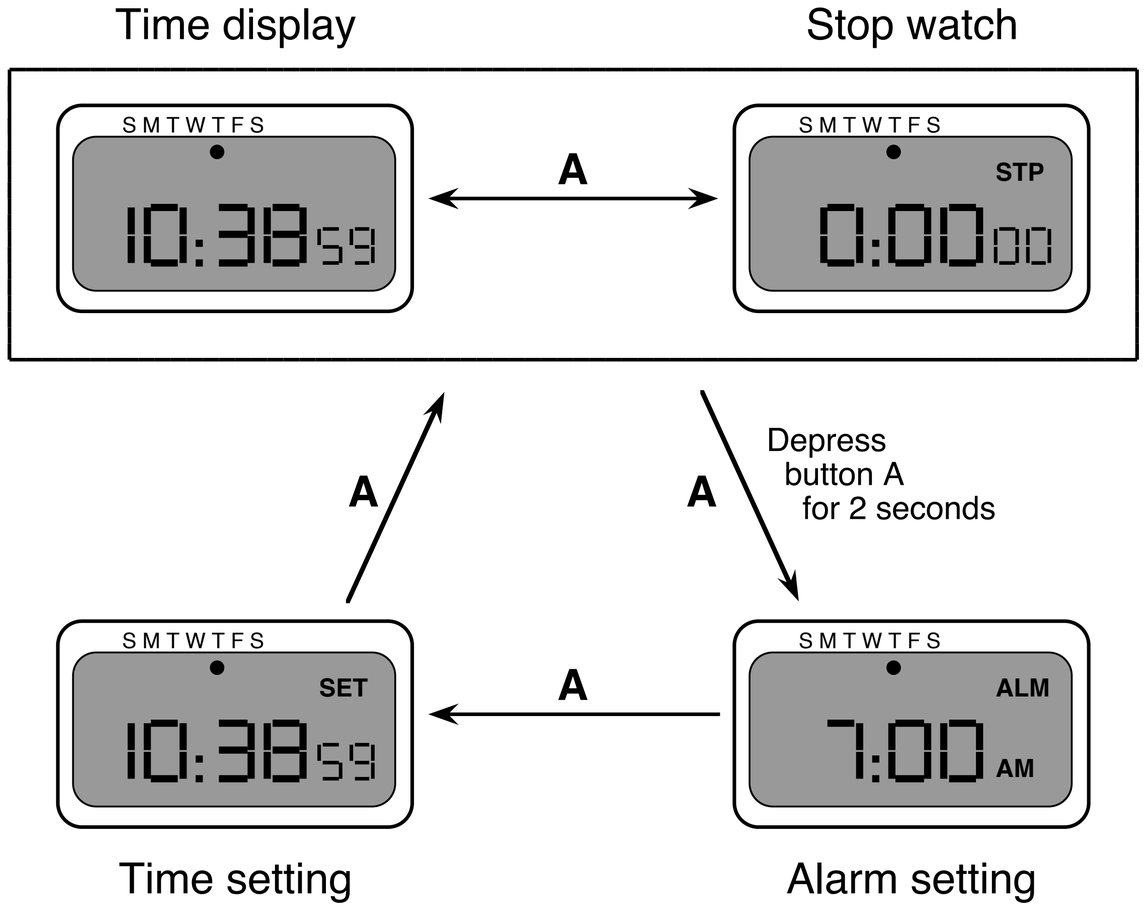
Diagrams For User Documentation

- Some dialog descriptions are clear enough to serve as user documentation (similar to GOMS)

- Especially if description uses screen shots and is semi-formal

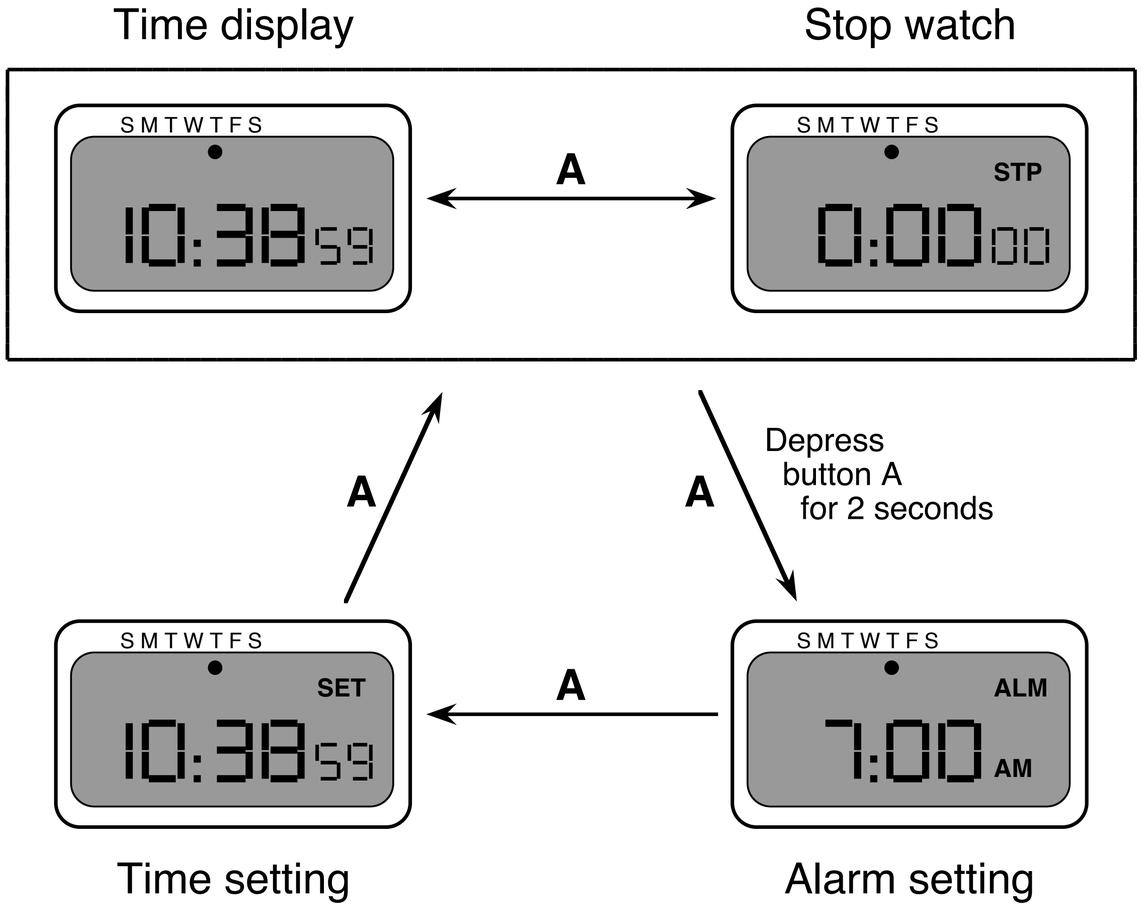
Digital Watch – User Instructions

- Two main modes
- Limited interface
  - 3 buttons
- Button A changes mode



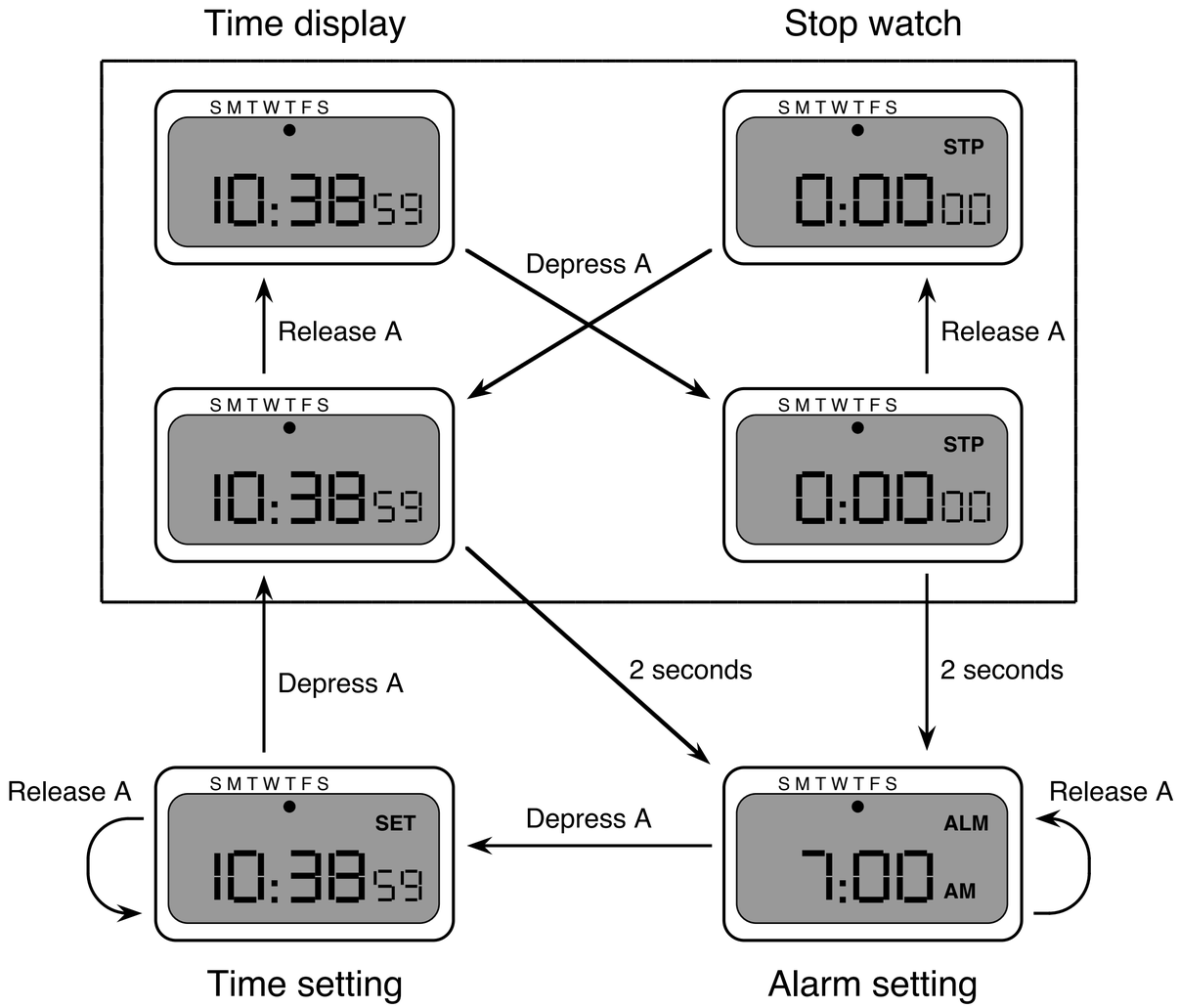
Digital Watch – User Instructions

- Dangerous states
- Completeness
  - Distinguish depress A and release A
  - What do they do in all modes?



Digital Watch – User Instructions

and… that's just one button



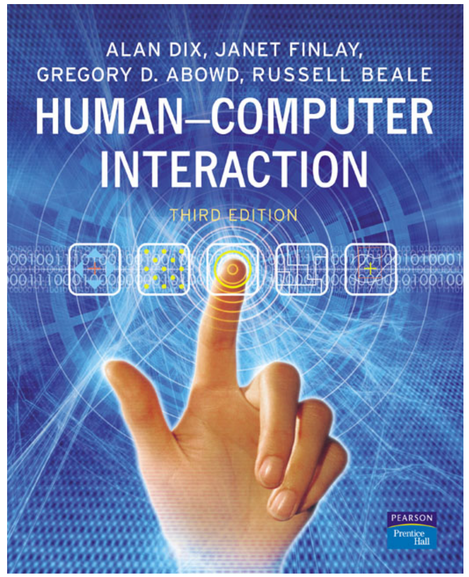
Semantics - Raw Code

- Event loop for word processor
- Dialogue description: very distributed
- Syntactic/semantic trade-off: terrible!

```
switch ( ev.type ) {
  case button_down:
    if ( in_text ( ev.pos ) ) {
        mode = selecting;
        mark_selection_start(ev.pos);
    }
    ...
  case button_up:
    if ( in_text ( ev.pos )
              && mode == selecting ) {
        mode = normal;
        mark_selection_end(ev.pos);
    }
    ...
  case mouse_move:
    if (mode == selecting ) {
        extend_selection(ev.pos);
    }
    ...
} /* end of switch */
```

Further Reading

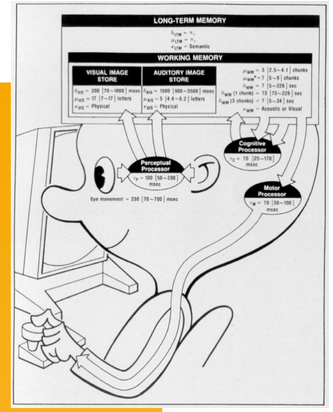
- Alan Dix et al.: Human-Computer Interaction, 3rd ed. (2003), Chapter 16



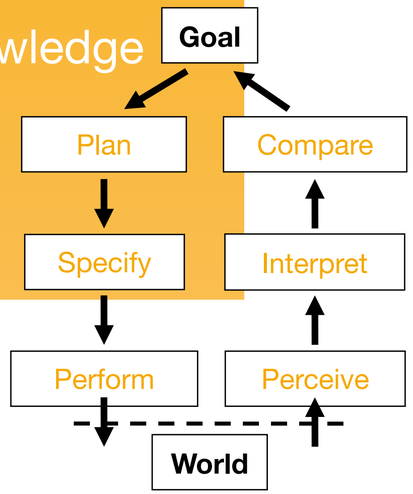
- Ben Shneiderman: Designing The User Interface, 5th ed. (2009), esp. Chapter 5

Roadmap

Human



- Performance
- Models of interaction
  - Affordances
  - Mappings
  - Constraints
  - Types of knowledge
  - Errors
- Visual Design

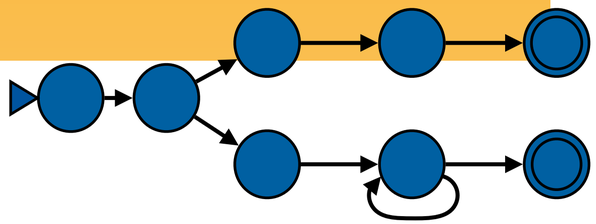


Case Studies

- History of HCI
- Visions
- Phases of Technology

Development Process

- Iterative design
- User observation
- Ideation
- Prototyping
- User studies and evaluation
- Interaction design notation



What's Next?

- **Designing Interactive Systems 2** (6 ECTS)
  https://hci.rwth-aachen.de/dis2
  - What makes a UI tick?
  - Technical concepts, software paradigms and technologies behind HCI and user interface development
- **Current Topics in HCI** (6 ECTS)
  https://hci.rwth-aachen.de/cthci
  - Understand & practice ways to do research in HCI
  - Learn about up-to-date developments in HCI and interactive multimedia from new books and recent conference/journal articles
- **Self-study in Summer 2021!**

What's Next?

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