Programming of Interactive Systems

Anastasia.Bezerianos@lri.fr

Based on Slides from Caroline Appert

Week 6:
b. State machines

Anastasia.Bezerianos@lri.fr

Inspired by Slides from Caroline Appert

Finite State Machines

States represent the state of your system:

- current window, active widgets, switching window…

Transitions are triggered by events:

- User events (mouse click, key press, …)
- System events (timeout, incoming packet, …)
- Custom events (gesture recognition, …)

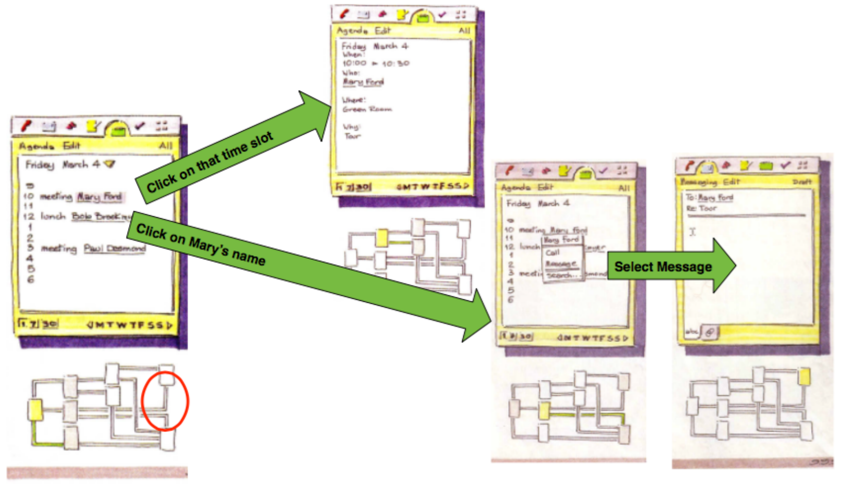
3

Finite State Machines

Finite state machines (FSM)

Can help you think of the system behavior and possible states before coding

Work at different levels (remember interaction storyboards?)



4

Describing **detailed** interactions

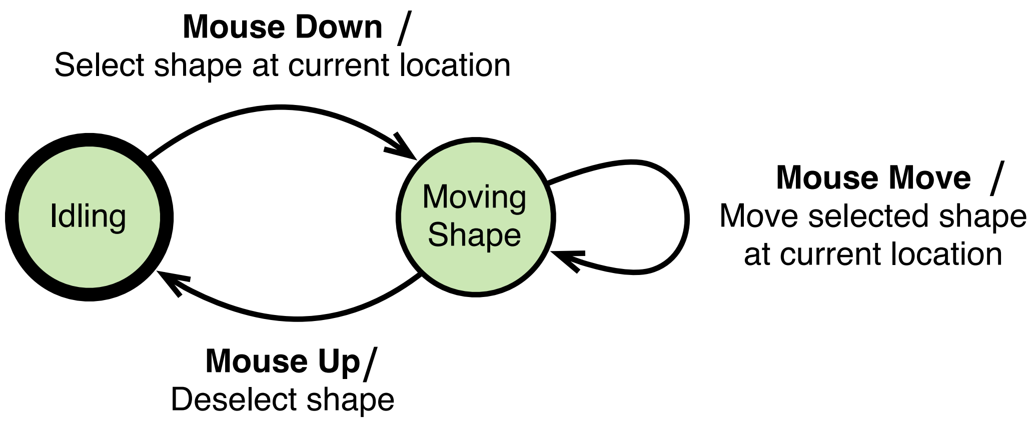
Finite state machines (FSM):

- **States** represent interaction states:
  - Idling, dragging, drawing, …
- **Transitions** are triggered by events:
  - User events (mouse click, key press, …)
  - System events (timeout, incoming packet, …)
  - Custom events (gesture recognition, …)

5

Example

Dragging a shape:

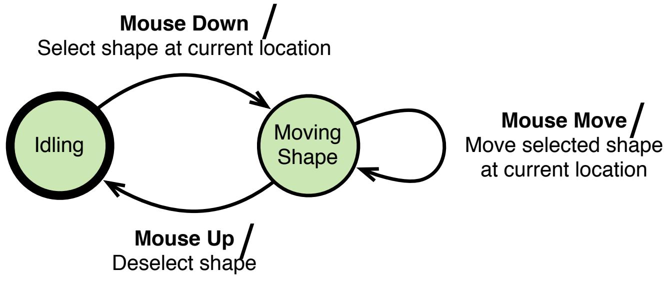


6

Example

Implementing this with callbacks/listeners:

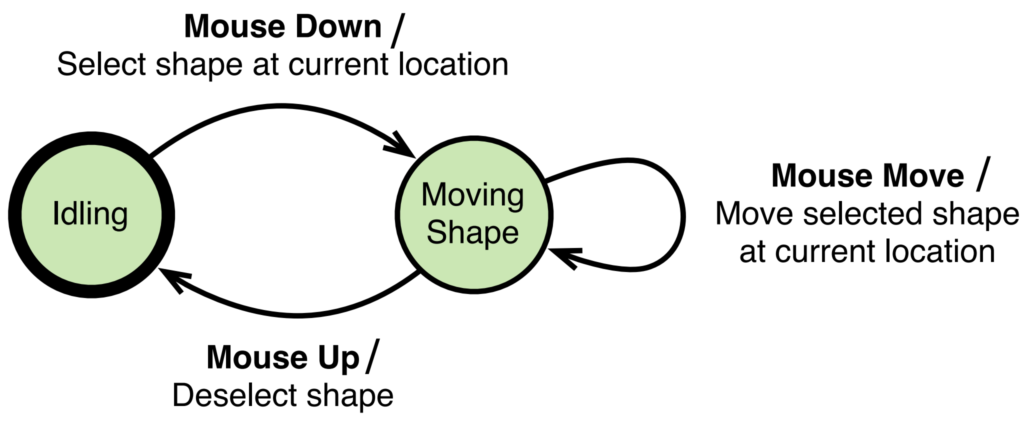
```
Shape dragged = null;
new MouseAdapter() {
  public void **mousePressed**(MouseEvent e) {
       // dragged is initialized, could call a function MouseDownState
  }
  public void **mouseReleased**(MouseEvent e) {
       // dragged is set back to null, could call a function IdleState
  }
}
new MouseMotionAdapter() {
  public void **mouseDragged**(MouseEvent e) {
       // dragged is translated, could call a function MovingShapeState
  }
}
```


Mouse Down /
Select shape at current location
Idling
Moving Shape
Mouse Move /
Move selected shape at current location
Mouse Up /
Deselect shape

7

Example

This is okay for simple state machines.

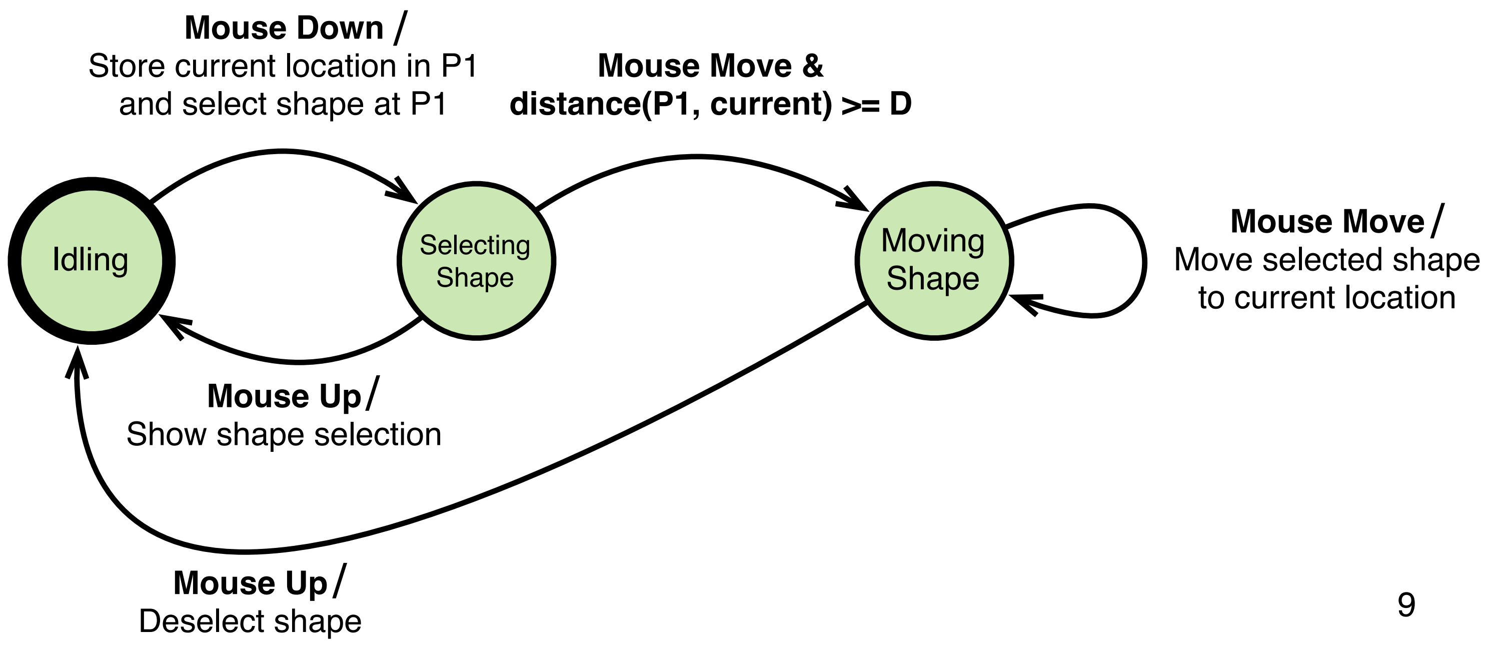


8

Example

This is okay for simple state machines.

Let's consider the ability to select and drag an object:



9

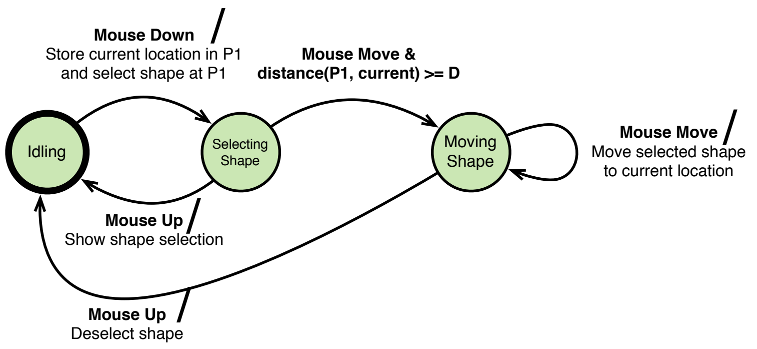
Example

Implementing the FSM with callbacks:

```
Shape dragged = null;
boolean dragging = false;

new MouseAdapter() {
   public void mousePressed(MouseEvent e) {
         // dragged is initialized
   }
   public void mouseReleased(MouseEvent e) {
         // dragged is set back to null
          // shape is selected if not dragged

   }
}
new MouseMotionAdapter() {
   public void mouseDragged(MouseEvent e) {
         if (!dragging) {
              // check if dragging occurs

          } else {

              // drag shape

          }

   }
}
```

State variables

Separate listeners



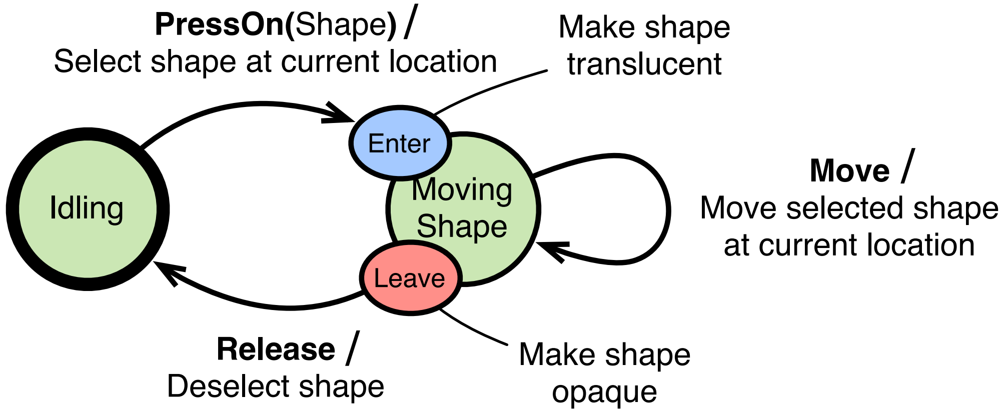
10

Enter / Leave

In general, the user should know in which state the system is. To that end, **actions** can be triggered when **entering** or **leaving** a state to express this change.

Example:

When being dragged, the shape becomes translucent:

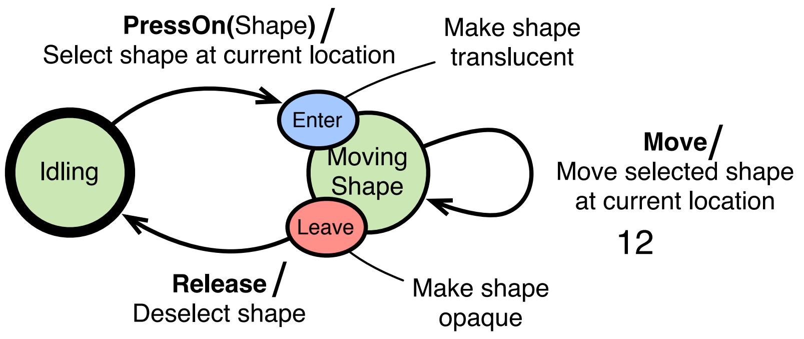


11

Enter/Leave

Implementing this with callbacks/listeners:

```
Shape dragged = null;

new MouseAdapter() {
  public void mousePressed(MouseEvent e) {
       // dragged is initialized, could do this in a separate function
       dragged = findShapeAt( e.getPoint() );
       dragged.setTransparent(true);
  }
  public void mouseReleased(MouseEvent e) {
       // dragged is set back to null, could do this in a separate function
       dragged = null;
       dragged.setTransparent(true);
  }
}
new MouseMotionAdapter() {
  public void mouseDragged(MouseEvent e) {
       // dragged is translated
  }
}
```



12

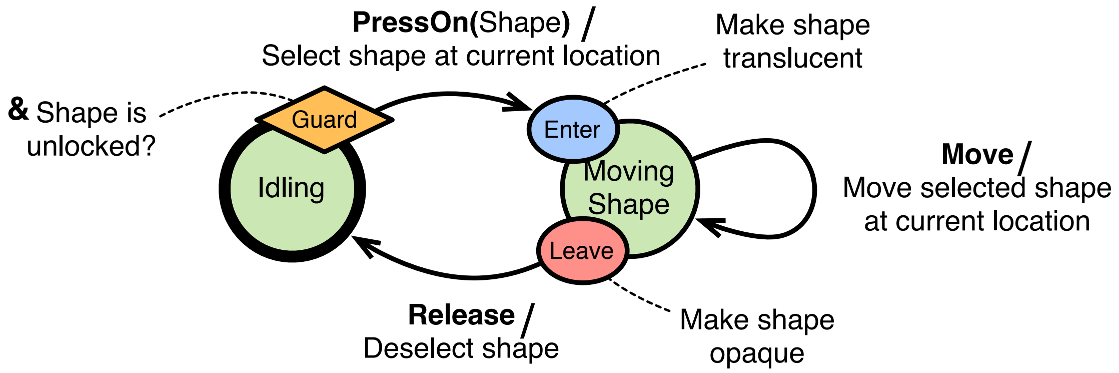
Guard

Transitions can be moderated by a **guard** (use & symbol in transition).

If the **boolean** it returns is true, the transition will happen.

Example:

Only **unlocked** shapes can be moved:



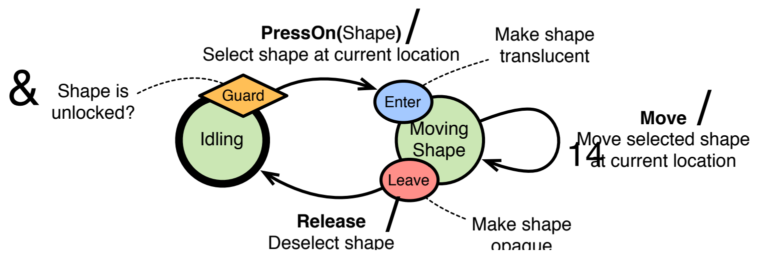
& Shape is unlocked?
Guard
Idling
PressOn(Shape) / Select shape at current location
Make shape translucent
Enter
Moving Shape
Leave
Move / Move selected shape at current location
Release / Deselect shape
Make shape opaque

13

Guard

Implementing this with callbacks/listeners:

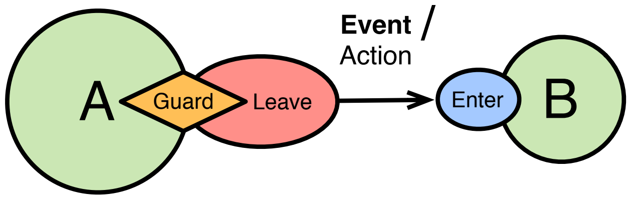
```
Shape dragged = null;
new MouseAdapter() {
  public void mousePressed(MouseEvent e) {
       // dragged is initialized, could do this in separate function
       dragged = PressOn( e.getPoint() );
       if ( dragged.unlocked )
              dragged.setTransparent(true);
       else
              dragged = null;
  }
  public void mouseReleased(MouseEvent e) {
       // dragged is set back to null, could do this in a separate function
       dragged = null;
       dragged.setTransparent(true);
  }
}
new MouseMotionAdapter() {
```



Calling Order

When a transition from a state A to a state B occurs, the following order should be followed:

- Transition.guard()
- StateA.leave()
- Transition.action()
- StateB.enter()



15

Transitions

Transitions define two event **properties**:

- the **type** (press, release, move, etc.)
- the optional **target** (element type, group, widget, etc.).

A transition can have no specific target, meaning it occurs solely based on the nature of the event.

- **Key events** and **custom events** are often target-less.
- **Move** events should be target-less (you should know the target already from a previous event)

Example Transitions

Target-less

Click
Press
Release
Drag
Move
- Enter
- Leave

KeyPress
KeyRelease
KeyType

TimeOut

To check for on shape or widget

ClickOnShape
PressOnShape
ReleaseOnShape
DragOnShape
MoveOnShape
EnterOnShape
LeaveOnShape

$\uparrow$

Shape events relate to specific shapes/items

17

State Machines can

help break down complex tasks:

looking at entire program, or widgets as state machines

organize code based on states:

easier to debug

help communicate behavior to others

graphically before writing code

Often we draw state machines when expecting complex interactions and state transitions

18

State Machines

Several UI programming libraries have

Finite State Machine extensions

e.g., SwingStates for Java Swing

or statecharts in javascript

19

example problem

20

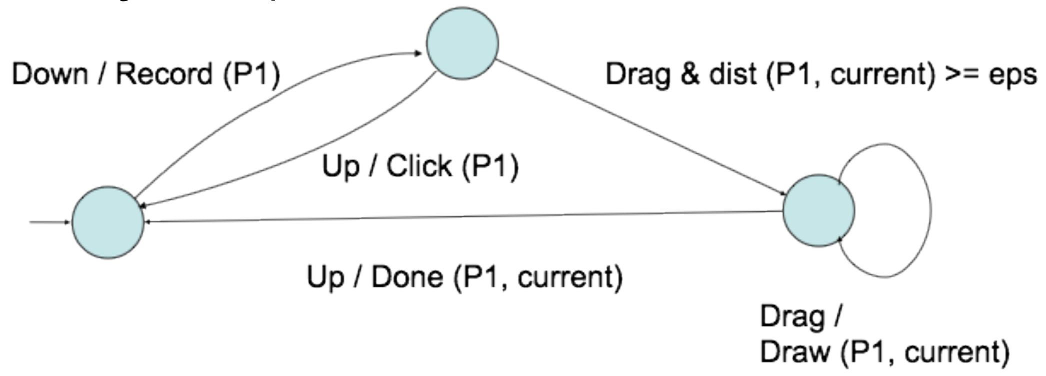
example problem

State machine reminder:

- State (circle) = interaction state NOT location of the application
- Transition (arc/link) = input events (Up, Down, Move, Drag, ...)

State machine

- actions associated with transitions (after the “/” symbol)
- guard conditions (boolean checks) associated with transitions (after the “&” symbol)

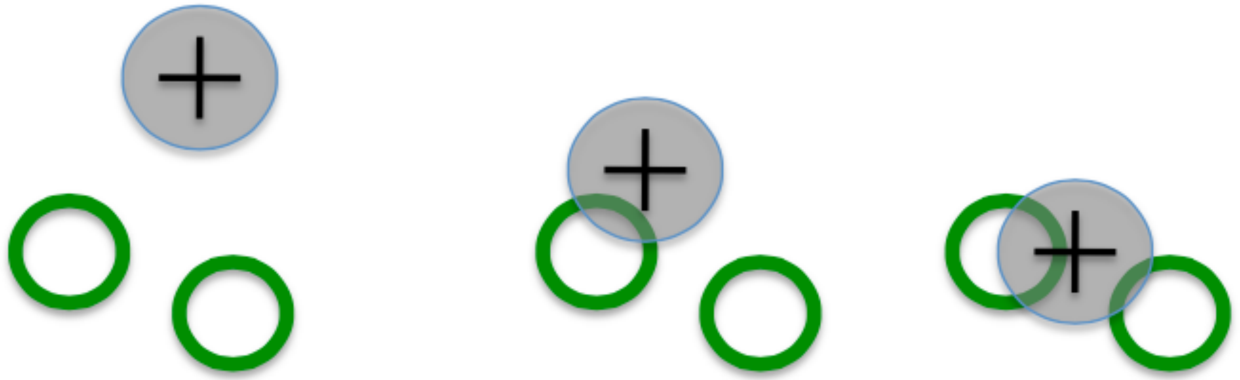


21

example problem

Create a state machine for a technique:

Area cursor: area around cursor, can click on targets when inside (in first image a click selects nothing, in the others it selects the left target)



example problem

Can use:

```
List = IntersectTargets (mousePos, WIDTH)
Target = ClosestTarget (mousePos, List)
```

23

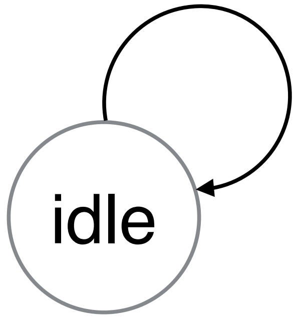
example solution

Low level user event

guard (find the closest object from the list of
all objects that are intersected by
area cursor of size WIDTH)

MousePress & (ClosestTarget (mousePos, IntersectTargets (mousePos, WIDTH)) ! null) **/**
t = ClosestTarget (mousePos, IntersectTargets (mousePos, WIDTH))
LaunchTargetClickedAction(t) // do stuff when target clicked

action during the transition,
get the closest object and
do stuff when it is clicked

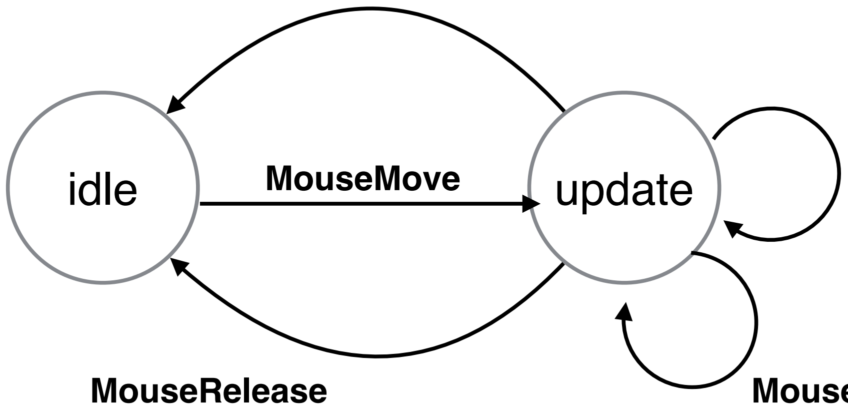


24

example solution 2

(that highlights closest target)

MousePress & (ClosestTarget (mousePos, IntersectTargets (mousePos, WIDTH)) ! null) **/**
t = ClosestTarget (mousePos, IntersectTargets (mousePos, WIDTH))
RemoveHighlightFromEveryTarget()
Hightlight(t)
LaunchTargetClickedAction(t) // do stuff when target clicked



MouseMove & (ClosestTarget (mousePos, IntersectTargets
(mousePos, WIDTH)) ! null) **/**
t = ClosestTarget (mousePos, IntersectTargets (mousePos, WIDTH))
RemoveHighlightFromEveryTarget()
Hightlight(t)

MouseRelease
RemoveHighlightFromEveryTarget()

MouseMove
RemoveHighlightFromEveryTarget()

Note:
RemoveHighlightFromEveryTarget() resets the colour of every target item
Highlight (t) highlights the item that can be selected by the area cursor, e.g. changing it's border to be thicker