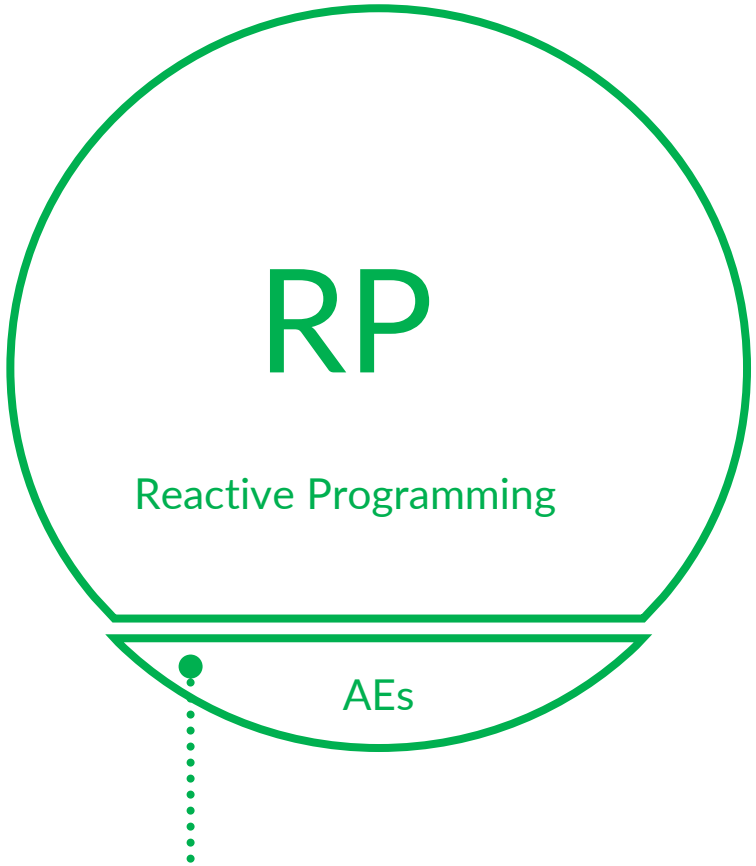
Explicit Tool Support for Implicit Layer Activation

Markus Brand, Stefan Ramson, Jens Lincke, Robert Hirschfeld
Software Architecture Group, Hasso Plattner Institute

Workshop on Context-Oriented Programming
and Advanced Modularity | 7th June 2022

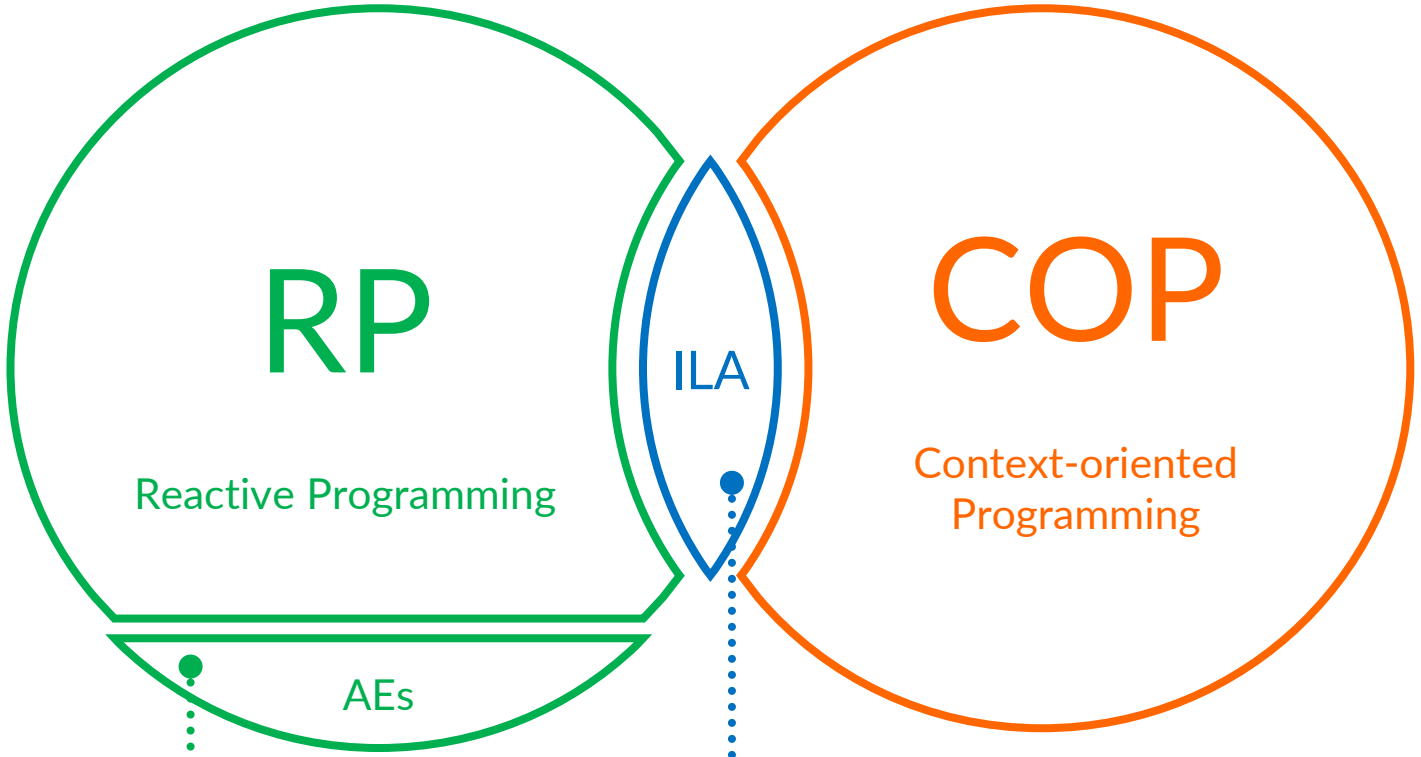
Context



Active Expressions
shared reactive primitive

COP?

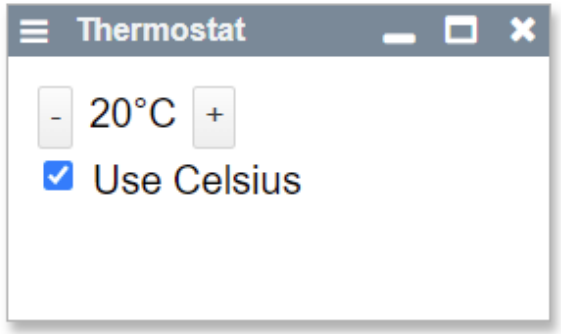
Context



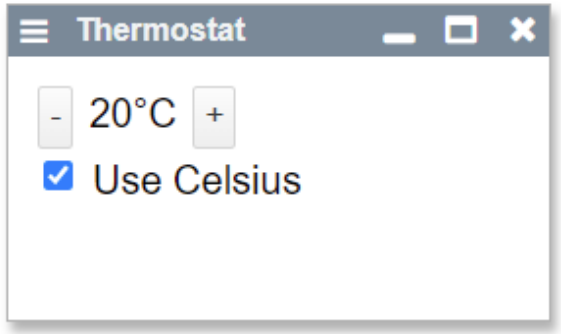
Active Expressions
shared reactive primitive

Implicit Layer Activation
activation means
with reactive semantics

Motivational Example



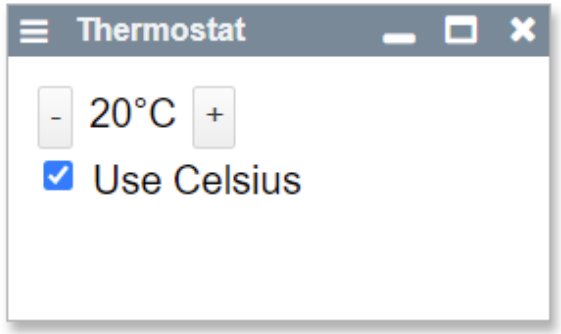
Updating the View




```
this.label.textContent = this.temperatureString()
```

```
temperatureString() {
  return this.celsius + "°C"
}
```

Reactive Programming Concept: Signals

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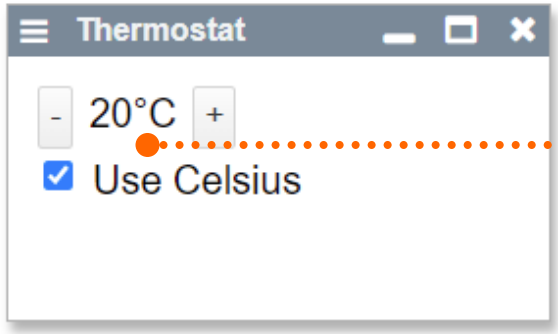
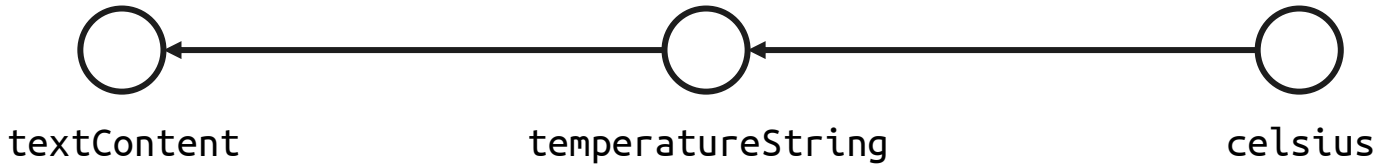
Functional Dependencies



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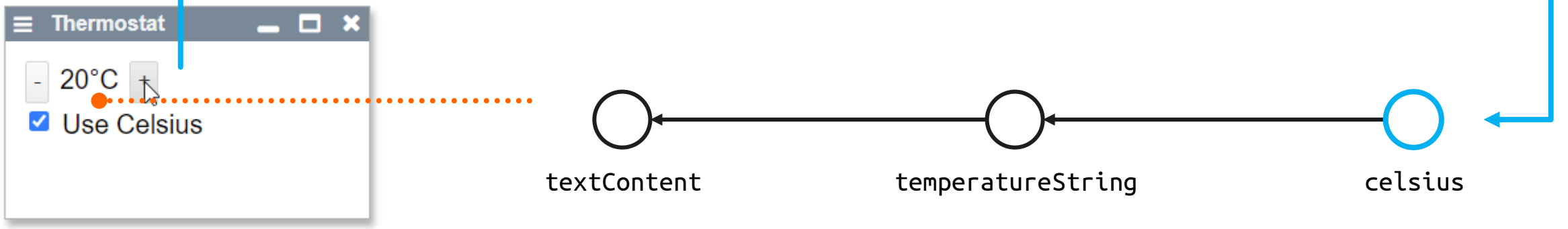
Automated Update Principle




```
increaseTemperature() {
  this.celsius++
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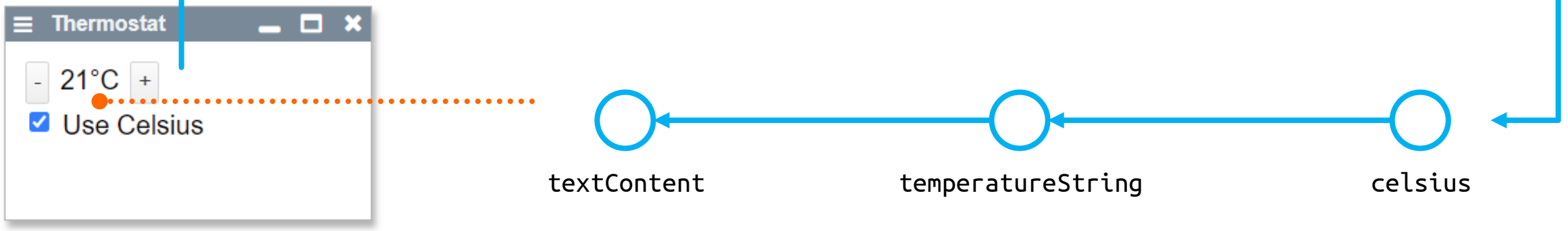


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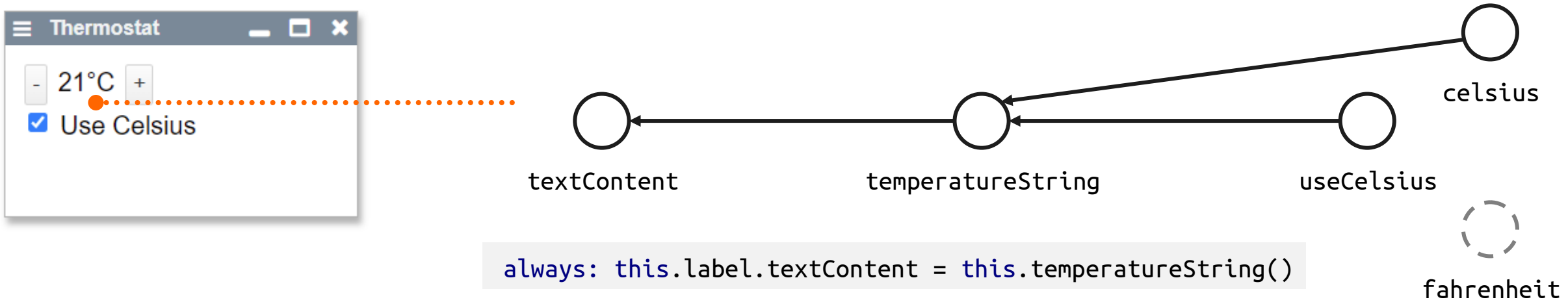
}
```

Adapting Behavior for Fahrenheit

```
increaseTemperature() {
  if (this.useCelsius)
    this.celsius++
  else
    this.fahrenheit++
}
```

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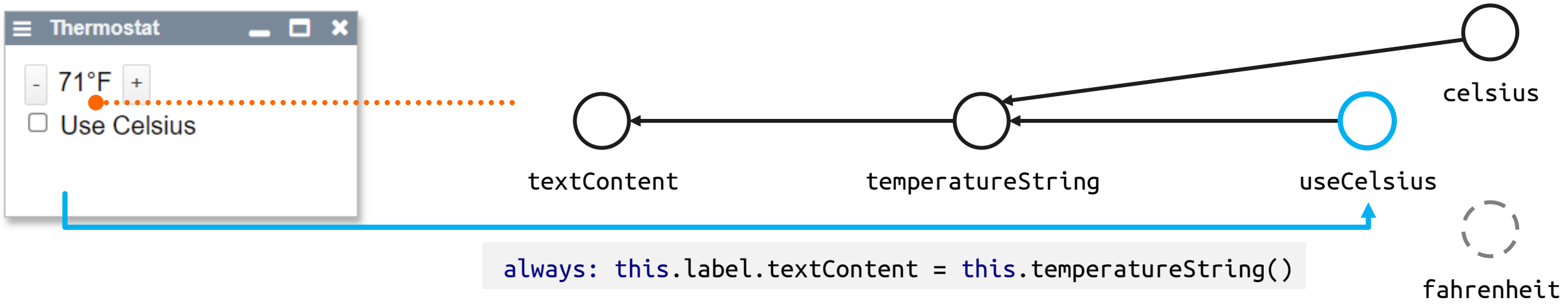


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```

Dynamic Network Topology

```
increaseTemperature() {
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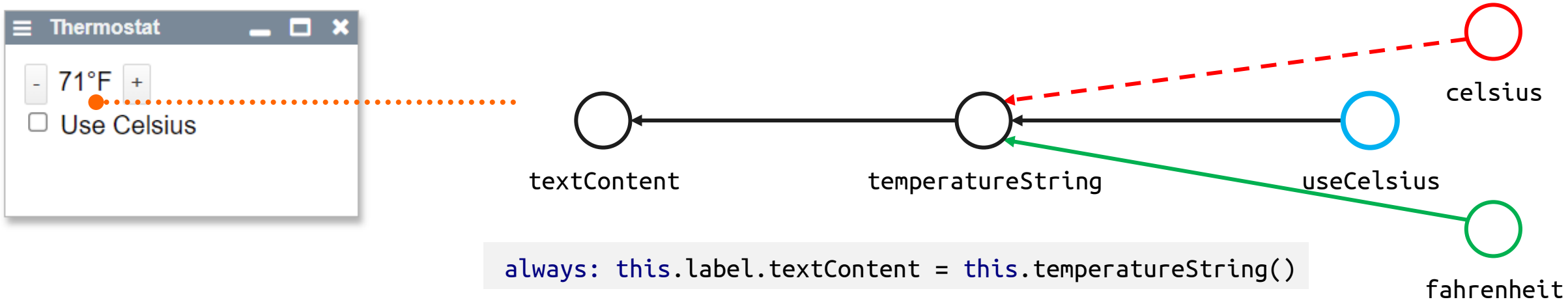
    this.celsius++
  else
    this.fahrenheit++
}
```

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Propagating Change

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increaseTemperature() {
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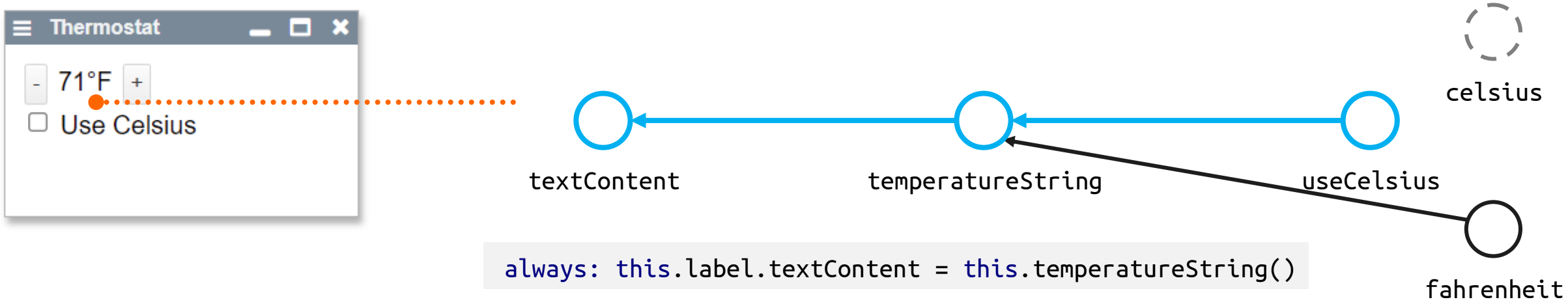
}
```

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Modularity Issues

duplicate code for **modes**

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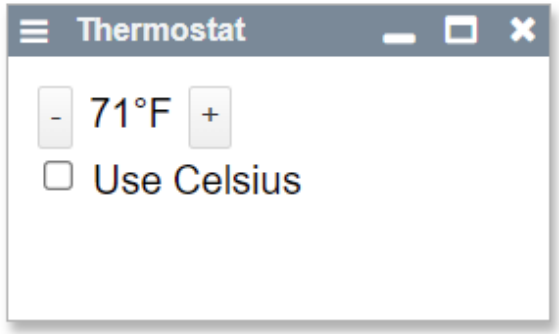
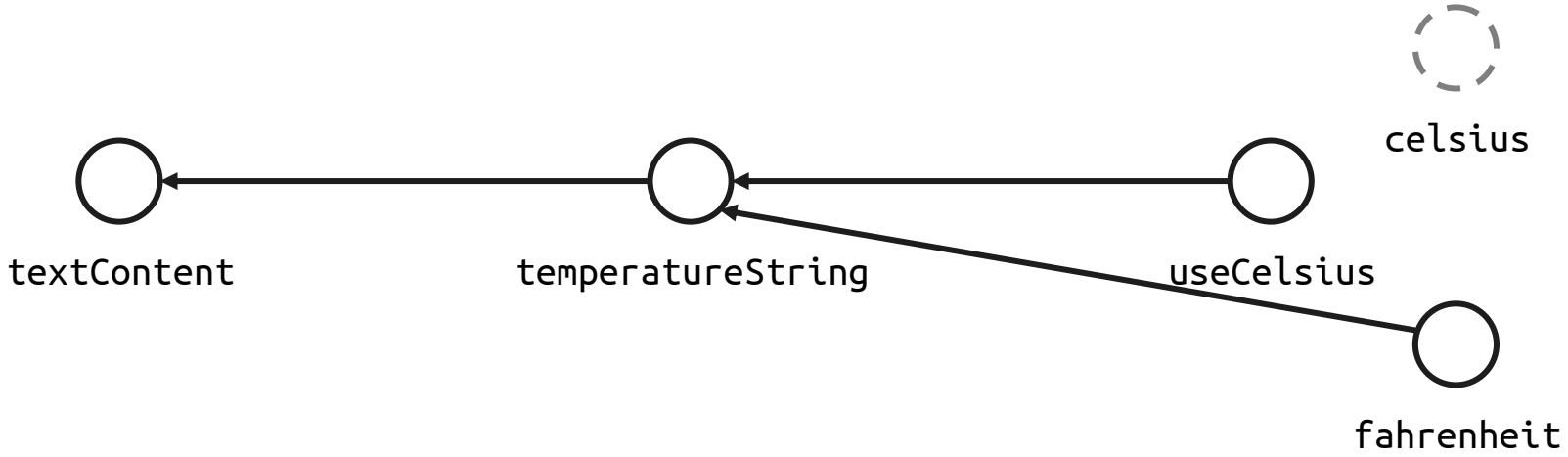
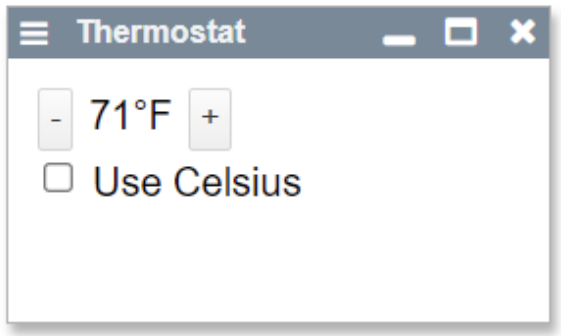
}
```






```
temperatureString() {
  if (this.useCelsius)
    return this.celsius + "°C"
  else
    return this.fahrenheit + "°F"
}
```

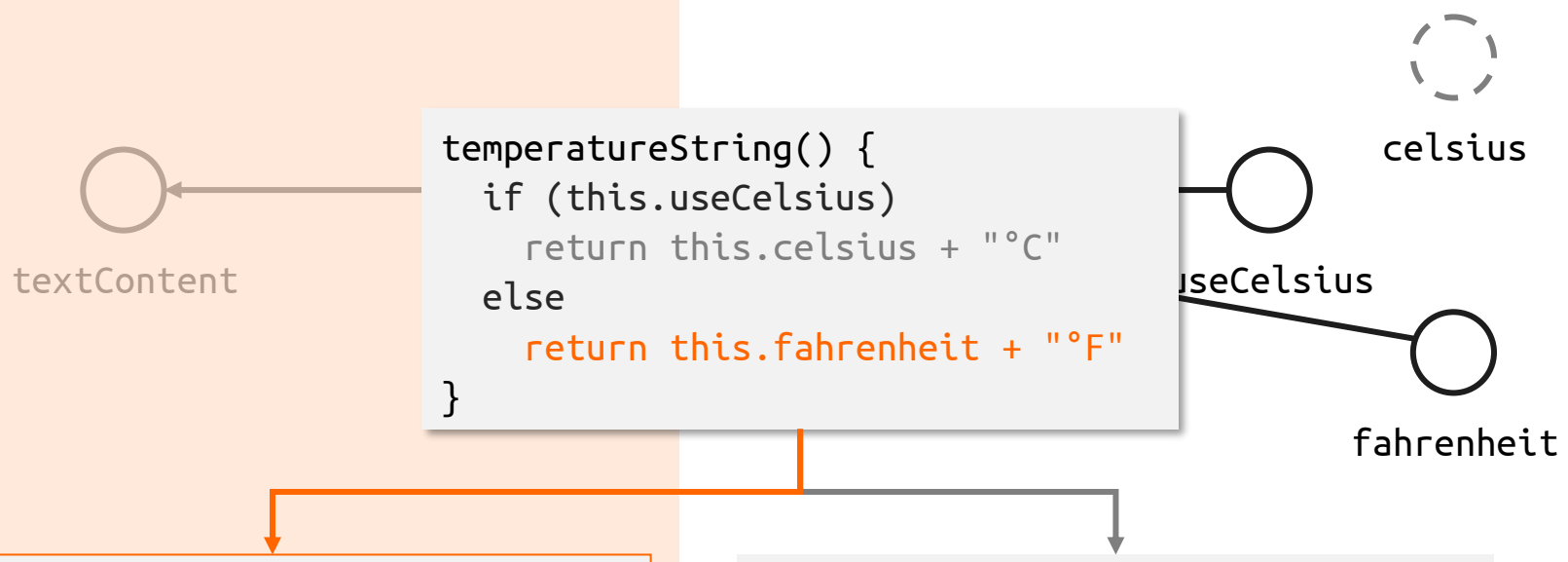
Extract Behavior into Partial Methods



Fahrenheit layer

```
increaseTemperature() {
  this.fahrenheit++
}
```

```
increaseTemperature() {
  this.celsius++
}
```




```
temperatureString() {
  return this.fahrenheit + "°F"
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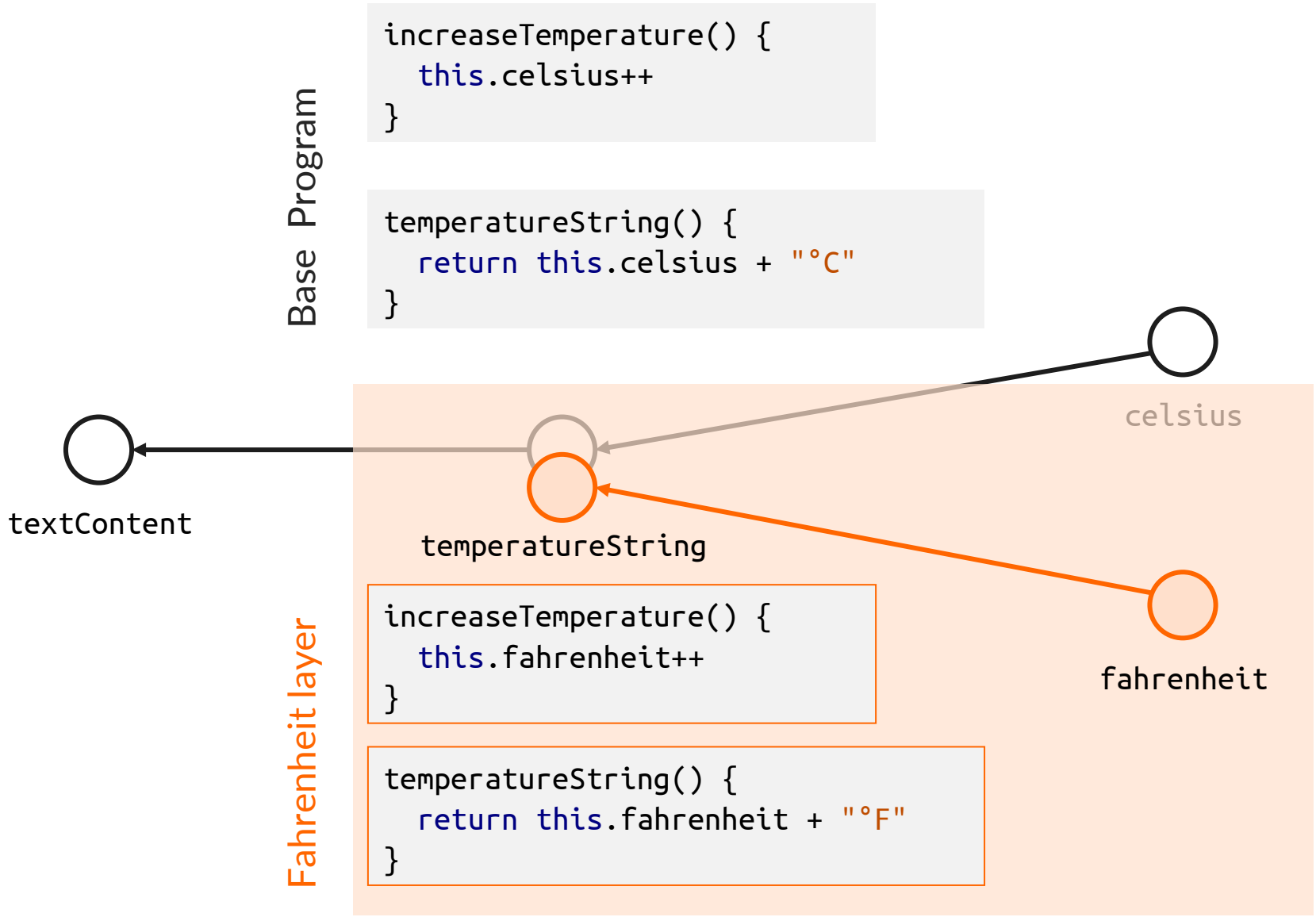
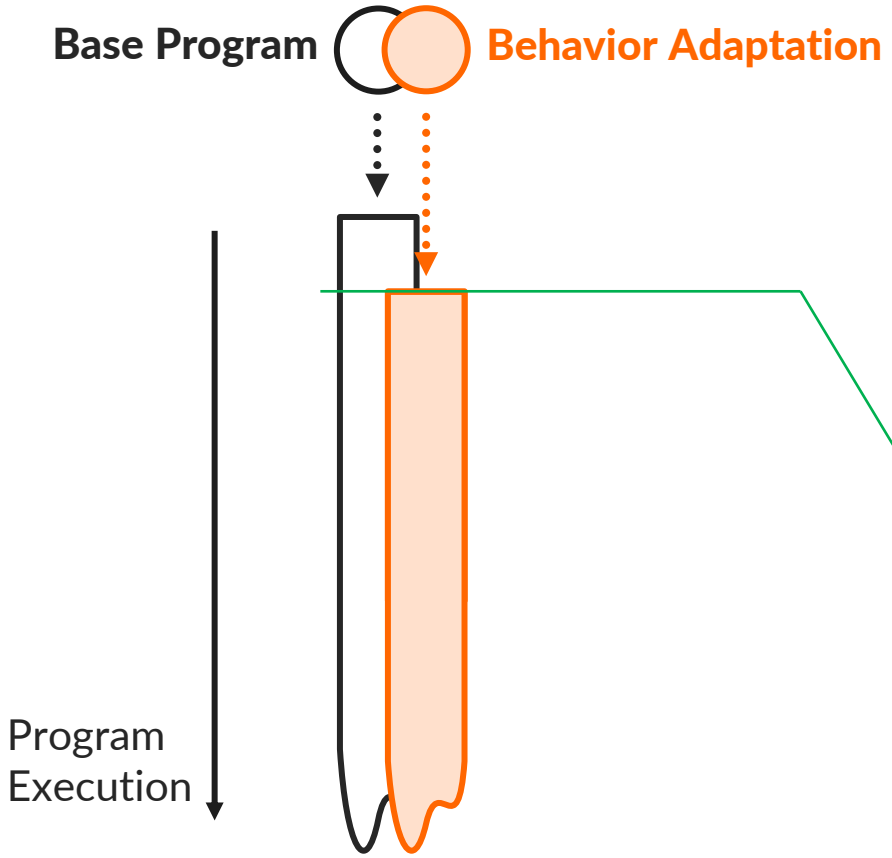
}
```

Expressing Modes



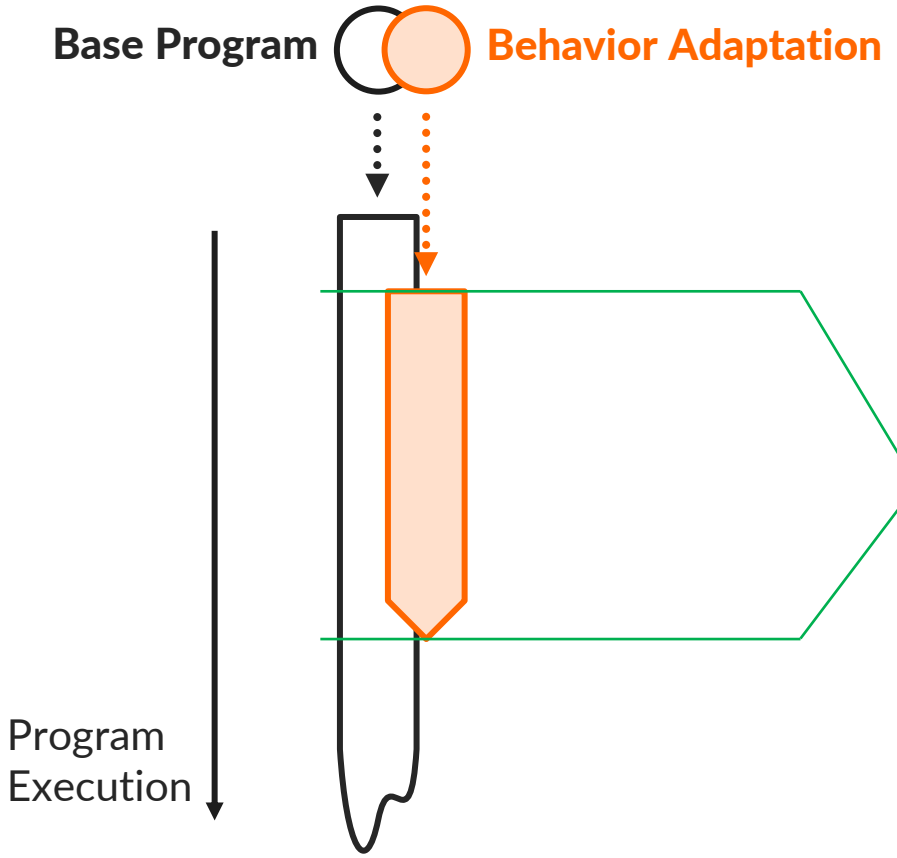
Global Layer Activation




```
fahrenheitLayer
  .refineObjectClass(thermostat, [...])
```

```
useCelsiusCheckbox.click = function() {
  if (this.checked)
    fahrenheitLayer.deactivate()
  else
    fahrenheitLayer.activate()
}
```

Global Layer Activation

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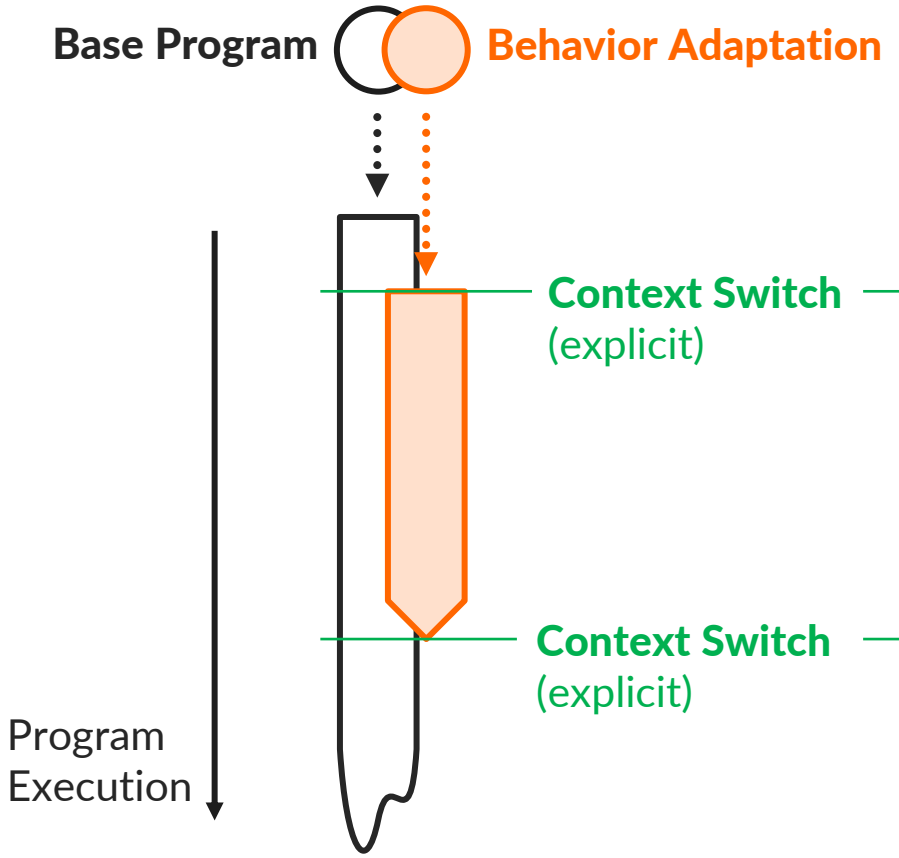
Context Transition

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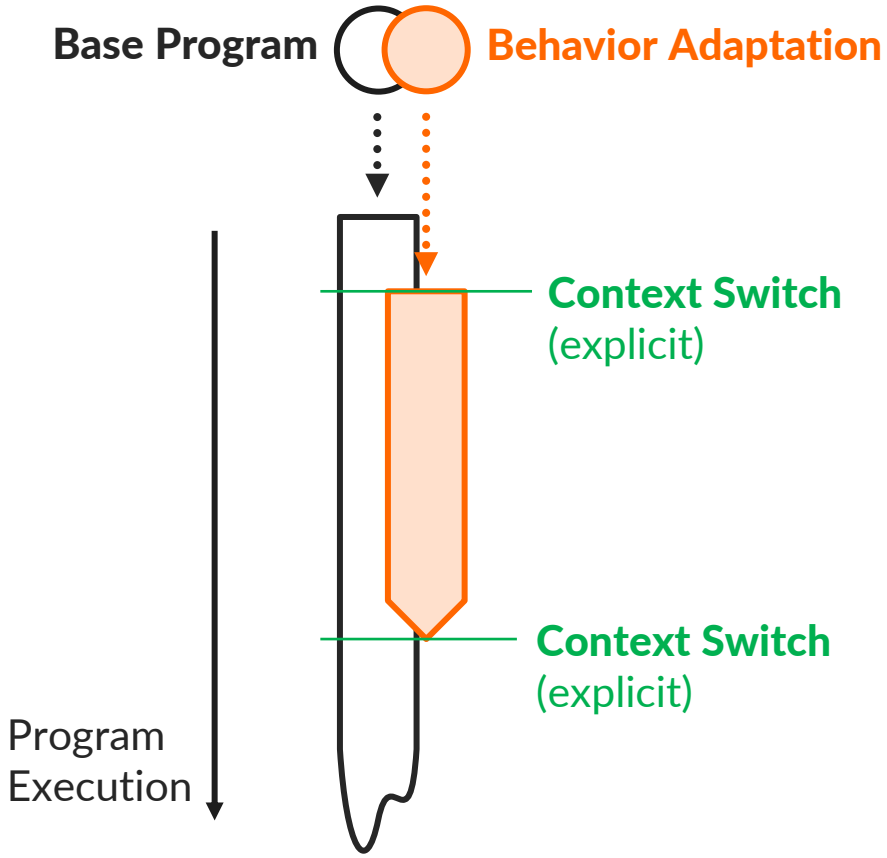
```

- Global Layer Activation
- Scope-based Layer Activation
- …

Transition versus Extent



- Global Layer Activation
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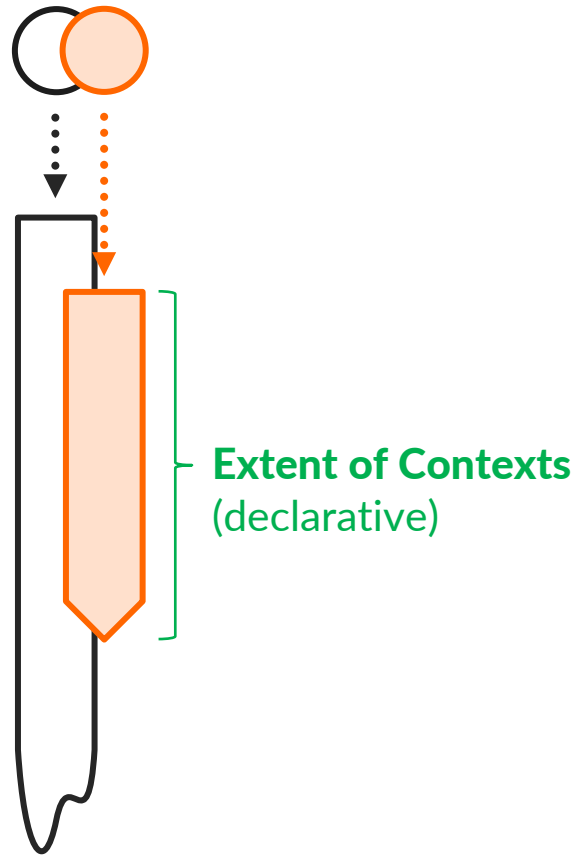


- Implicit Layer Activation

Implicit Layer Activation (ILA)

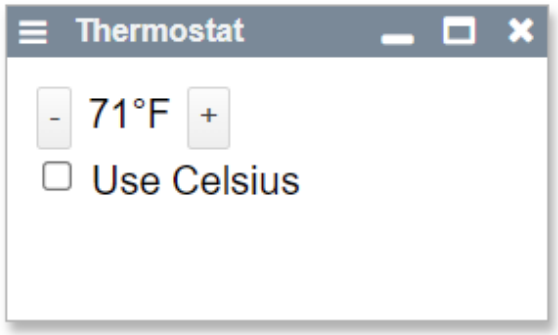
Activation means to **declaratively** define the extent of a layer activation

Activation status of a layer bound to a **Boolean predicate**:

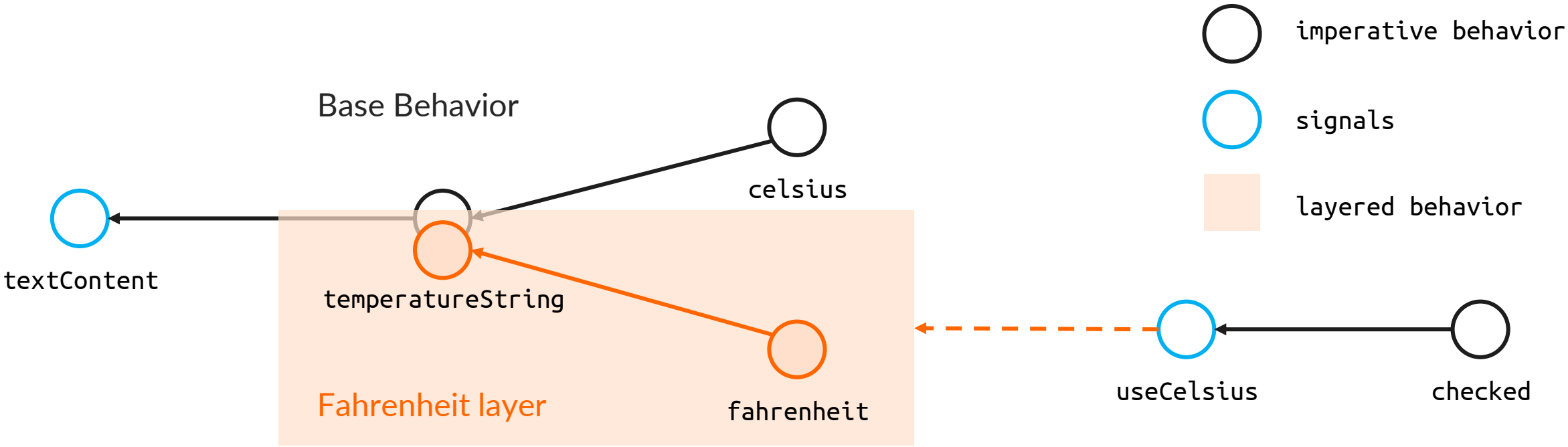
```
layer.activeWhile(condition)
```

Martin von Löwis, Marcus Denker, and Oscar Nierstrasz. 2007. **Context-oriented Programming: Beyond Layers.** In International Conference on Dynamic Languages (ICDL), 2007. ACM, 143–156. DOI:https://doi.org/10.1145/1352678.1352688

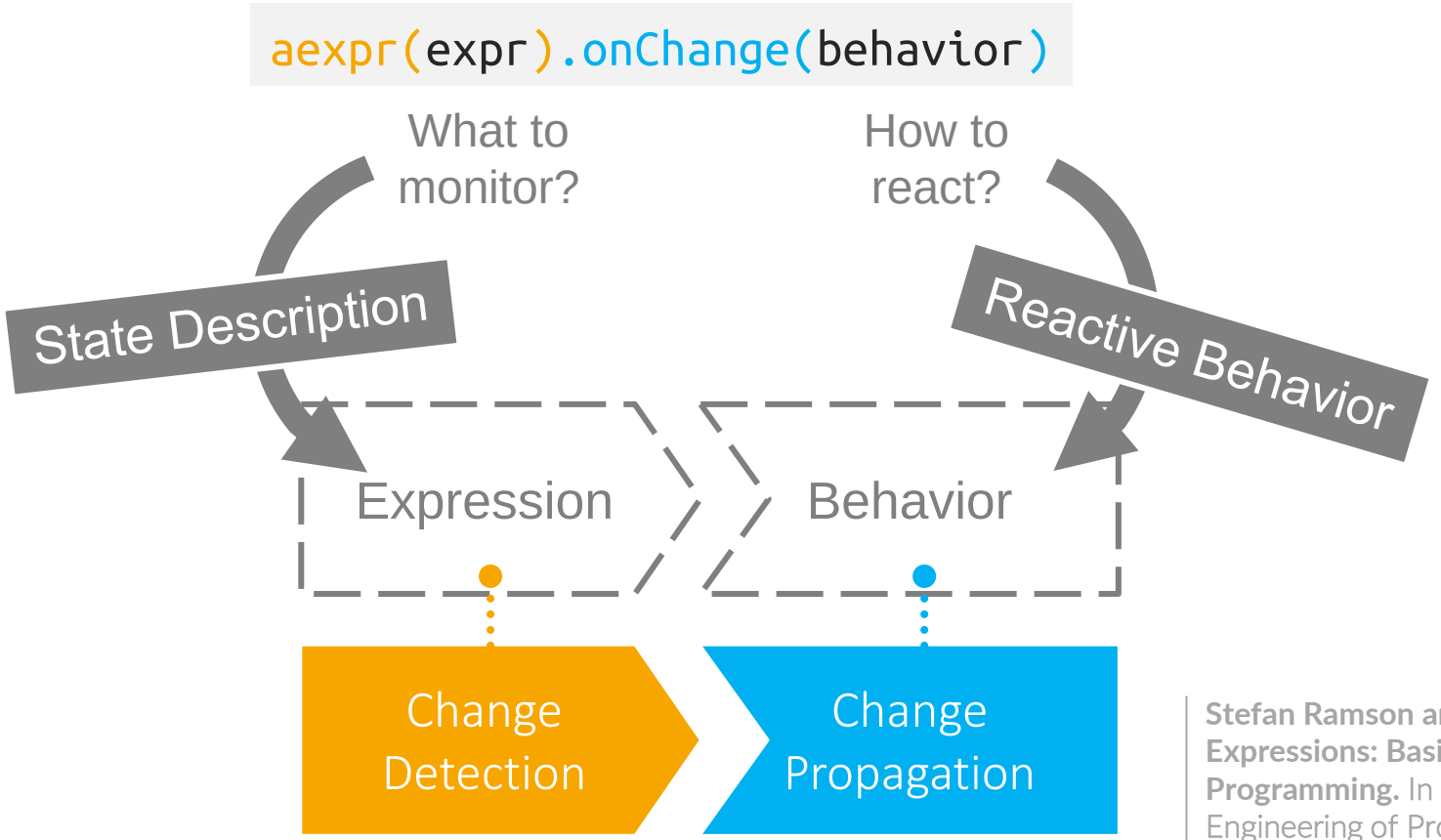
Extract Behavior into Partial Methods




```
this.fahrenheitLayer.activeWhile(() => !this.useCelsius)
```



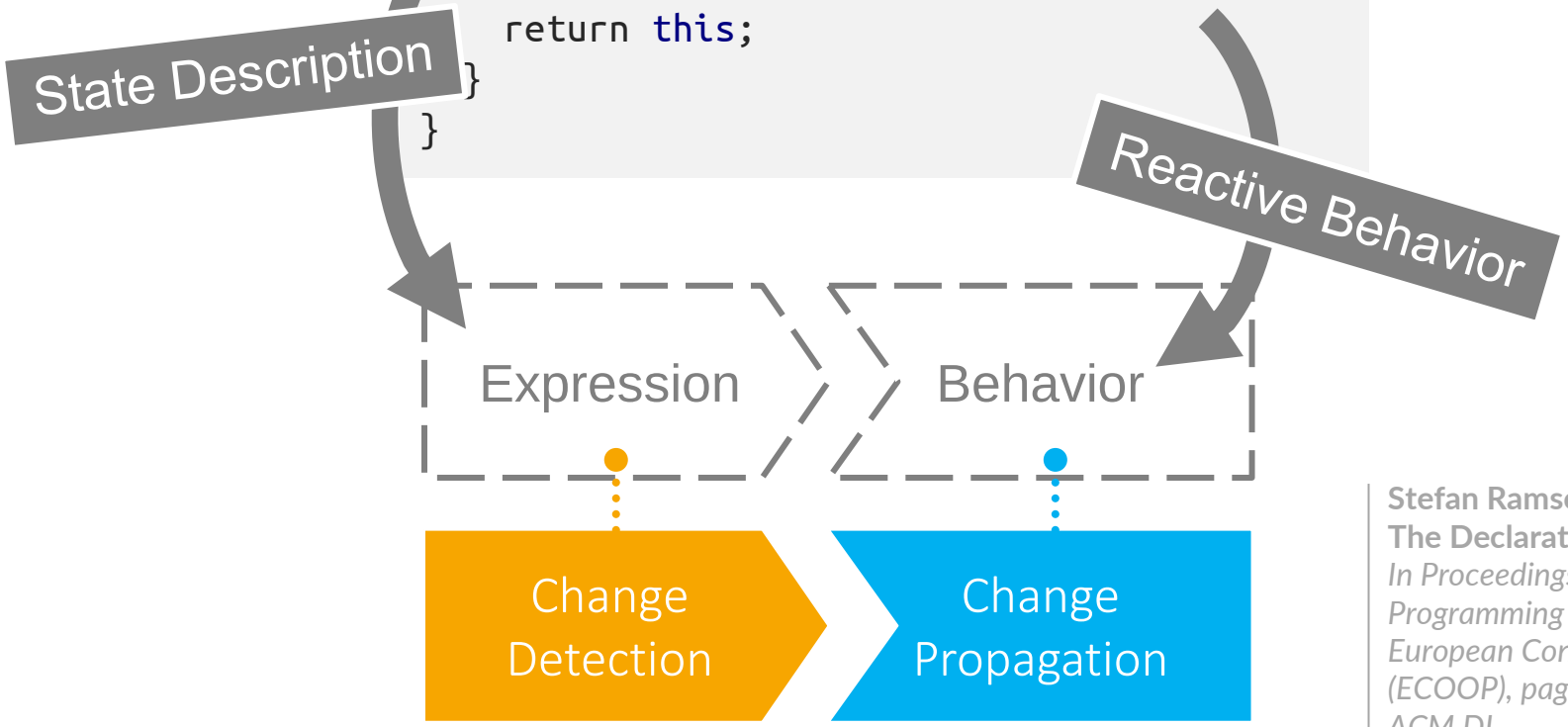
Active Expressions, a Reactive Primitive



Stefan Ramson and Robert Hirschfeld. Active Expressions: Basic Building Blocks for Reactive Programming. In Journal on The Art, Science, and Engineering of Programming, vol. 1, no. 2, art. 12, 49 pages, 2017.

ILA Implementation (Active Expressions)

```
class Layer {
  [...]
  activeWhile(condition) {
    aexpr(condition)
      .onBecomeTrue(::this.activate)
      .onBecomeFalse(::this.deactivate);
    return this;
  }
}
```



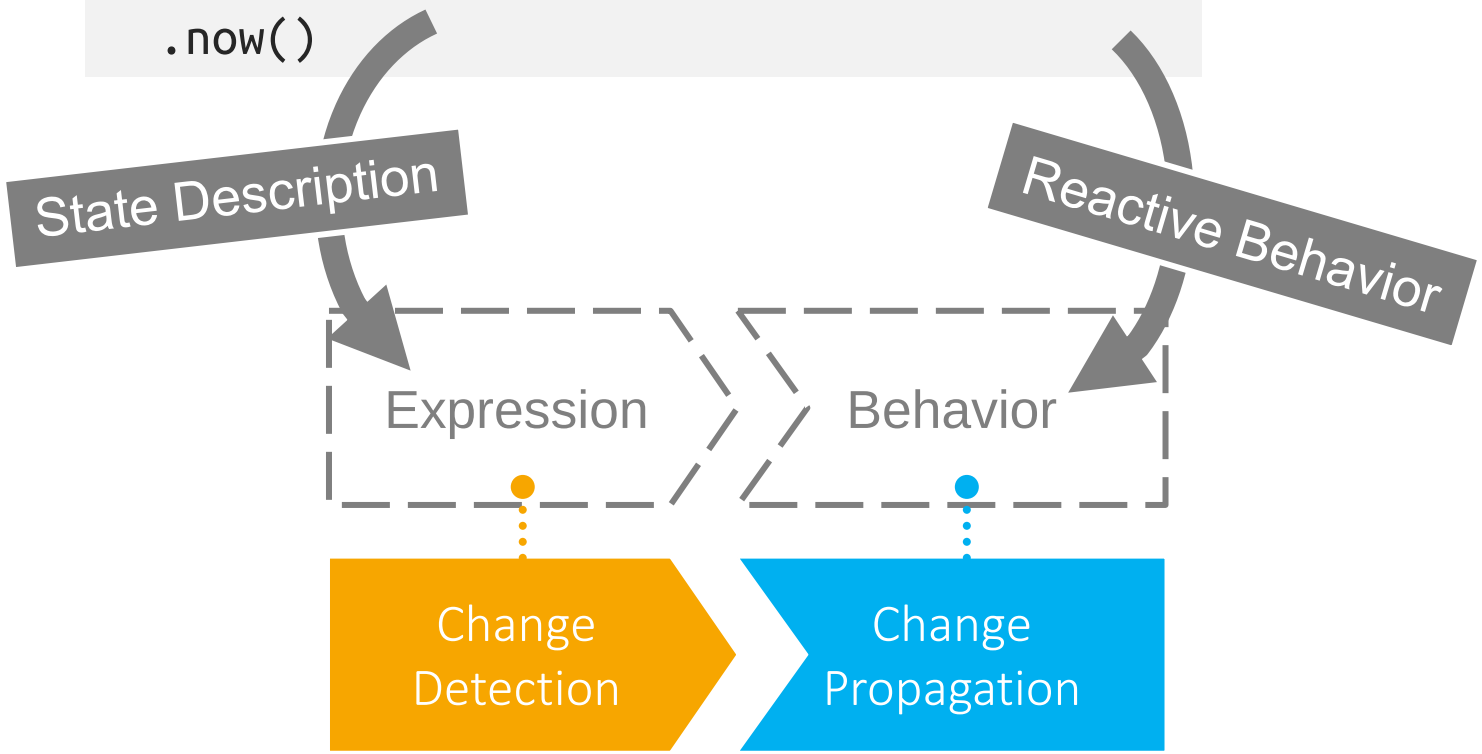
Stefan Ramson, Jens Lincke, and Robert Hirschfeld. **The Declarative Nature of Implicit Layer Activation.** *In Proceedings of the Workshop on Context-oriented Programming (COP) 2017, co-located with the European Conference on Object-oriented Programming (ECOOP), pages 7-16, Barcelona, Spain, June 20, 2017, ACM DL.*

Signal Implementation (Active Expressions)

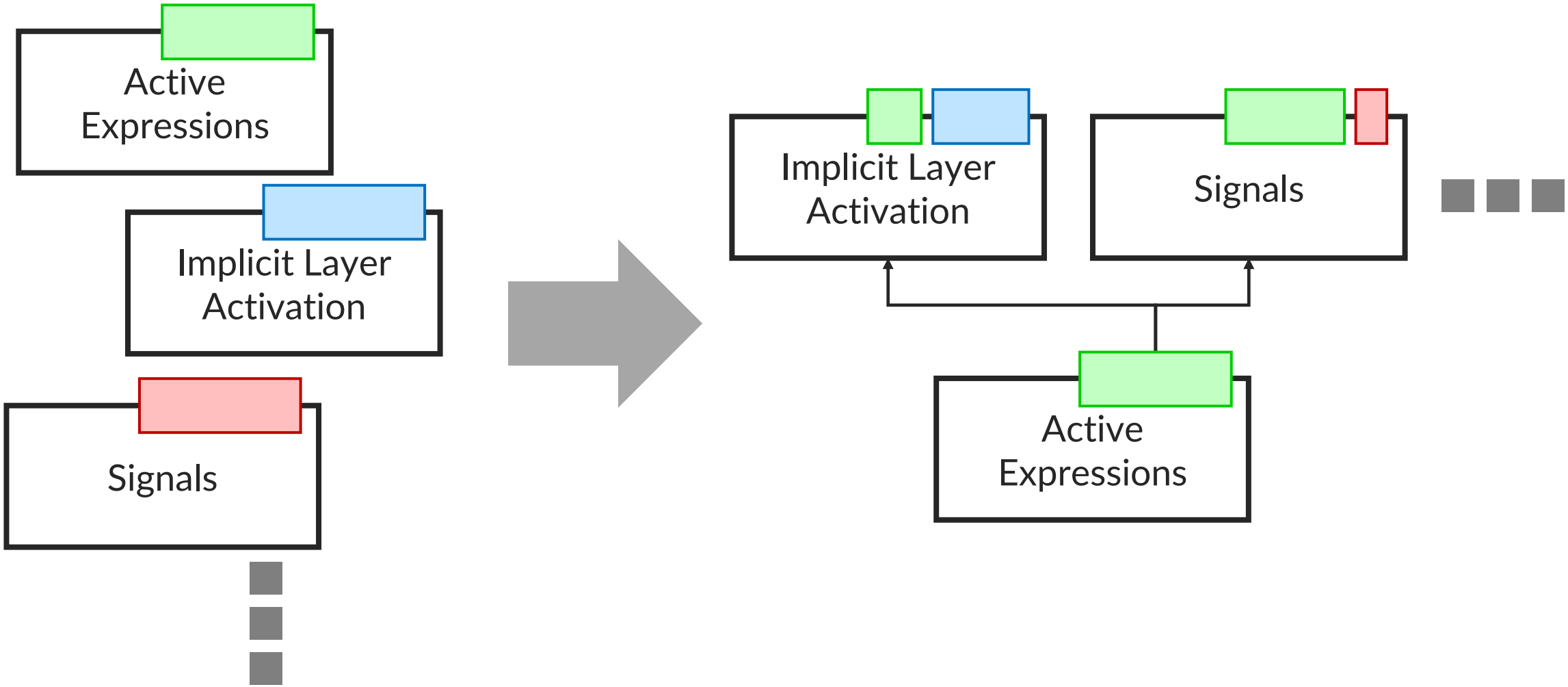
```
always: signal = expr
```

transpile to

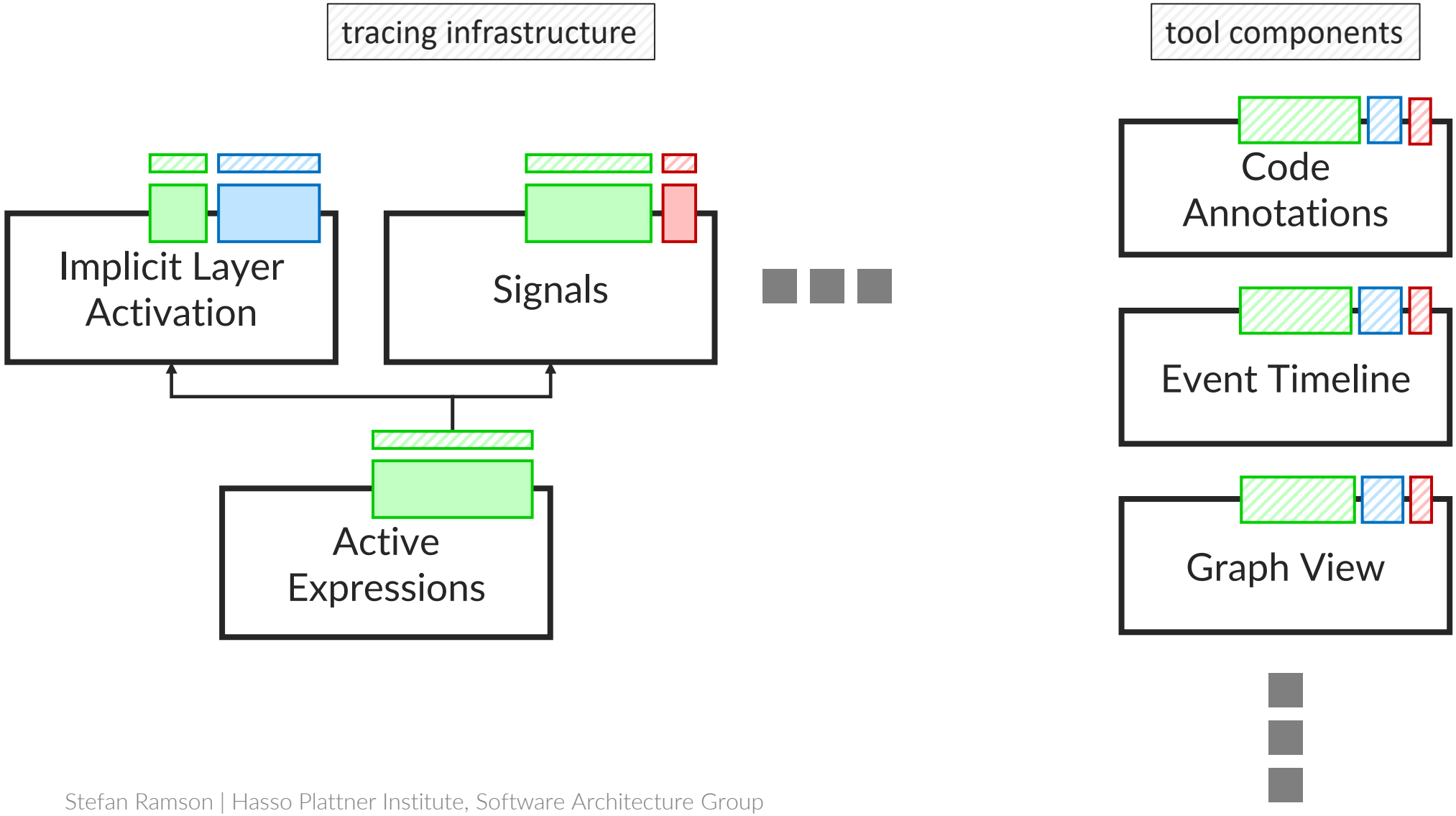
```
signal = aexpr(expr)
  .onChange(_value => signal = _value)
  .now()
```



Active Expressions as a Common Primitive



Opportunity for a Shared Tool Environment

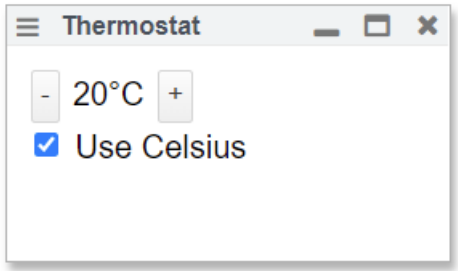


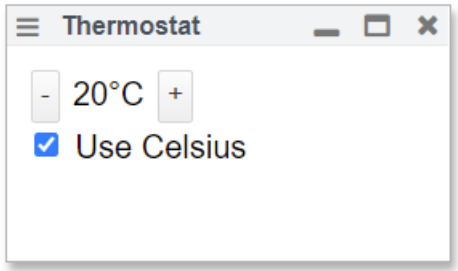
DEMO

Debugging the Thermostat

~Squeak in a browser

a live, self-sustaining, Web-based development environment

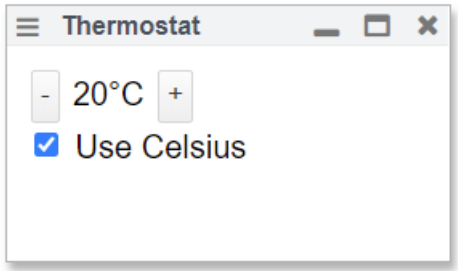

Thermostat
-
20°C
+
Use Celsius



thermostat-component.js

https://lively-kernel.org/lively4/aexpr/src/client/reactive/components/rewritten/the

```
1  "enable aexpr";
2
3  import Morph from 'src/components/widgets/lively-morph.js';
4  import { proceed, Layer } from 'src/client/ContextJS/src/Layers.js';
5
6  export default class Thermostat extends Morph {
7    async initialize() {
8      this.windowTitle = "Thermostat";
9      this.aexprs = [];
10     this.celsius = 20;
11
12     this.increase.addEventListener("click", () => {
13       this.increaseTemperature();
14     });
15     this.reduce.addEventListener("click", () => {
16       this.reduceTemperature();
17     });
18 SI  always: this.temperature.textContent = this.temperatureString();
19
20 SI  always: this.useCelsius = this.celsiusMode.checked;
21     this.setupLayer();
22
23 IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25     this.replaceMigratableAEs();
26   }
27
28   increaseTemperature() {
29     this.celsius++;
30   }
31
32   reduceTemperature() {
33     this.celsius--;
34   }
```



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24        mplicit Layer                    0 deps ▸
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26    }
27
28    increaseTemperature() {
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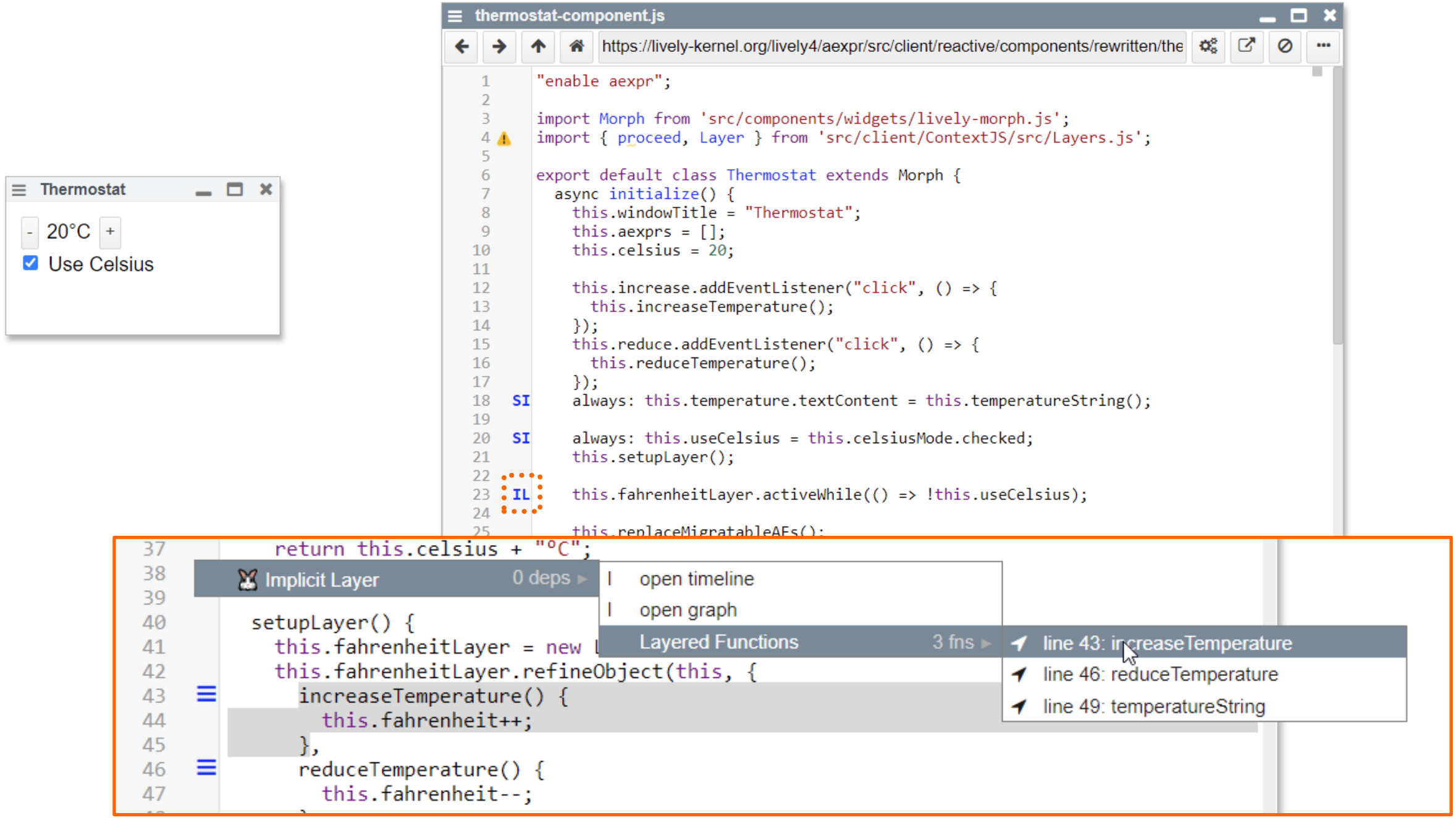
30    }
```

open timeline
open graph
Layered Functions 3 fns ▸


Thermostat
- 20°C +
Use Celsius
thermostat-component.js
https://lively-kernel.org/lively4/aexpr/src/client/reactive/components/rewritten/the
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import { proceed, Layer } from 'src/client/ContextJS/src/Layers.js';
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});
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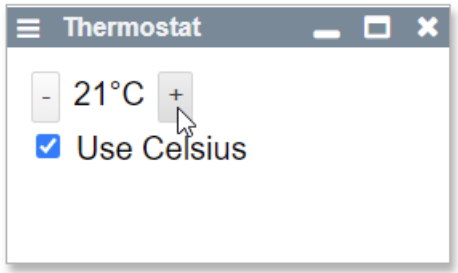
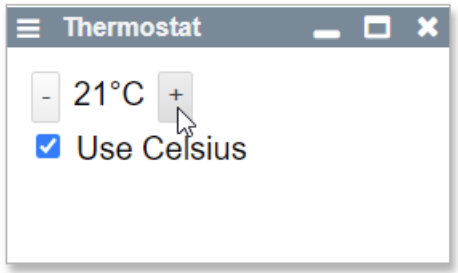
SI always: this.useCelsius = this.celsiusMode.checked;
this.setupLayer();
IL this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
this.replaceMigratableAEs();
return this.celsius + "°C";
Implicit Layer
0 deps
open timeline
open graph
Layered Functions
3 fns
line 43: increaseTemperature
line 46: reduceTemperature
line 49: temperatureString
setupLayer() {
this.fahrenheitLayer = new
this.fahrenheitLayer.refineObject(this, {
increaseTemperature() {
this.fahrenheit++;
},
reduceTemperature() {
this.fahrenheit--;



thermostat-component.js

https://lively-kernel.org/lively4/aexpr/src/client/reactive/components/rewritten/the

```
1   "enable aexpr";
2
3   import Morph from 'src/components/widgets/lively-morph.js';
4   import { proceed, Layer } from 'src/client/ContextJS/src/Layers.js';
5
6   export default class Thermostat extends Morph {
7     async initialize() {
8       this.windowTitle = "Thermostat";
9       this.aexprs = [];
10      this.celsius = 20;
11
12      this.increase.addEventListener("click", () => {
13        this.increaseTemperature();
14      });
15      this.reduce.addEventListener("click", () => {
16        this.reduceTemperature();
17      });
18  SI  always: this.temperature.textContent = this.temperatureString();
19
20  SI  always: this.useCelsius = this.celsiusMode.checked;
21      this.setupLayer();
22
23  IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25      this.replaceMigratableAEs();
26    }
27
28    increaseTemperature() {
29      this.celsius++;
30    }
31
32    reduceTemperature() {
33      this.celsius--;
34    }
```



thermostat-component.js

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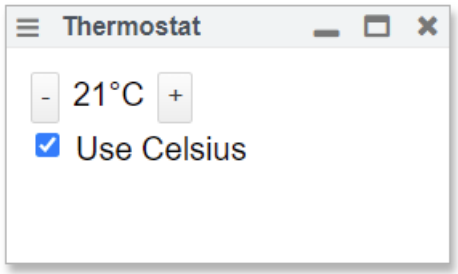
23  IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25      this.replaceMigratableAEs();
26    }
27
28    increaseTemperature() {
29      this.celsius++;
30    }
31
32    reduceTemperature() {
33      this.celsius--;
34    }
```



thermostat-component.js

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```
1  "enable aexpr";
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14     });
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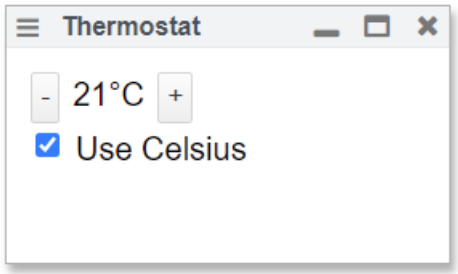
22
23 IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25     this.replaceMigratableAEs();
26   }
27
28   increaseTemperature() {
29     this.celsius++;
30     Signal                                  1 dep ▸
31
32   reduceTemperature() {
33     this.celsius--;
34   }
```

open timeline
open graph
line 18: 1 event



thermostat-component.js

https://lively-kernel.org/lively4/aexpr/src/client/reactive/components/rewritten/the

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2
3   import Morph from 'src/components/widgets/lively-morph.js';
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13        this.increaseTemperature();
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19
20  SI  always: this.useCelsius = this.celsiusMode.checked;
21      this.setupLayer();
22
23  IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25      this.replaceMigratableAEs();
```

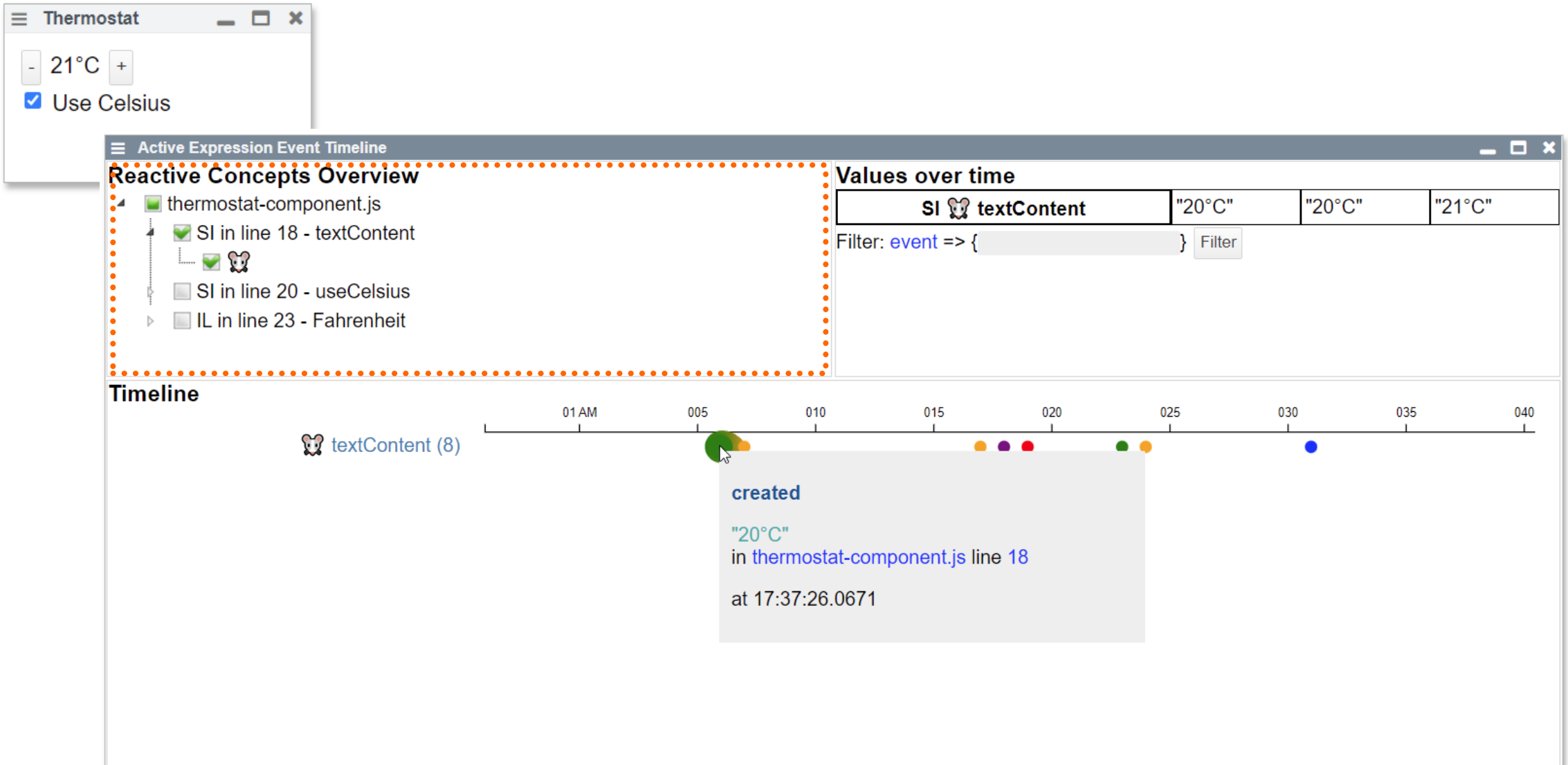
```
increaseTemperature() {
  this.celsius++;
}

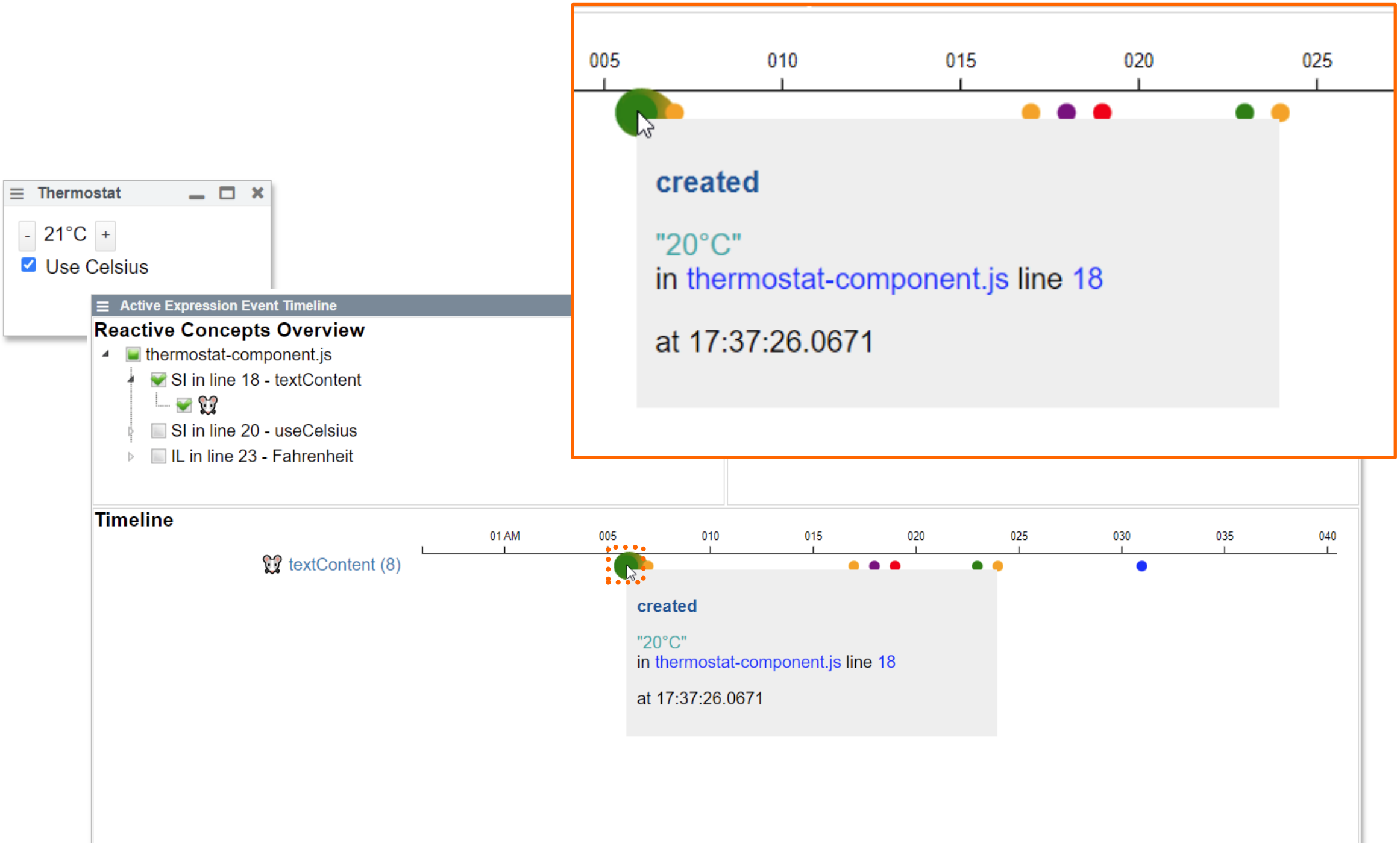
reduceTemperature() {
  this.celsius--;
}
```

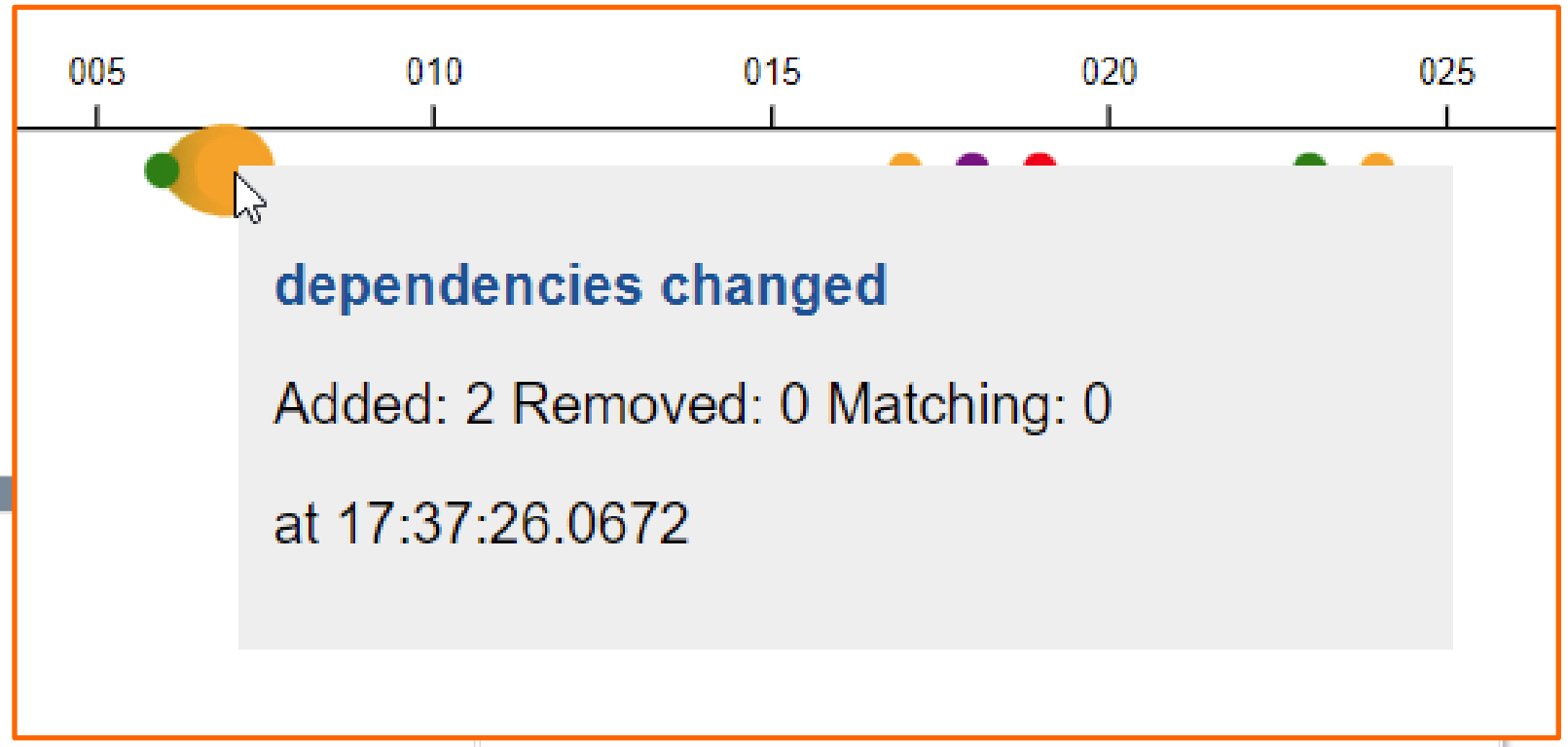
Signal 1 dep ▸

- open timeline
- open graph
- line 18: 🐭 1 event

Thermostat
- 21°C +
Use Celsius
Active Expression Event Timeline
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Values over time
SI textContent
"20°C"
"20°C"
"21°C"
Filter: event => { } Filter
Timeline
01 AM
005
010
015
020
025
030
035
040
textContent (8)
created
"20°C"
in thermostat-component.js line 18
at 17:37:26.0671


Thermostat
- 21°C +
Use Celsius
Active Expression Event Timeline
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Values over time
SI textContent
"20°C"
"20°C"
"21°C"
Filter: event => { } Filter
Timeline
01 AM
005
010
015
020
025
030
035
040
textContent (8)
created
"20°C"
in thermostat-component.js line 18
at 17:37:26.0671


005
010
015
020
025
created
"20°C"
in thermostat-component.js line 18
at 17:37:26.0671
Thermostat
- 21°C +
Use Celsius
Active Expression Event Timeline
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Timeline
01 AM
005
010
015
020
025
030
035
040
textContent (8)
created
"20°C"
in thermostat-component.js line 18
at 17:37:26.0671



Thermostat

- 21°C +

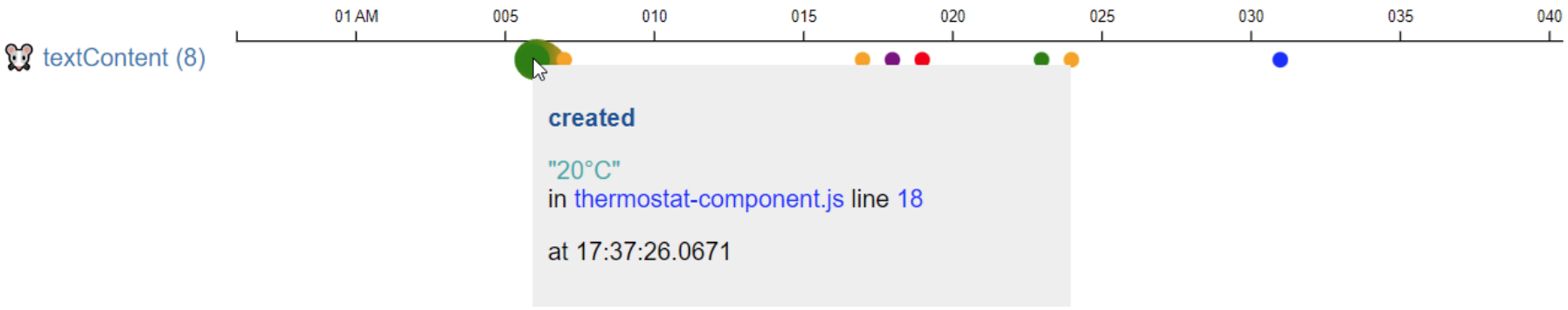
Use Celsius

Active Expression Event Timeline

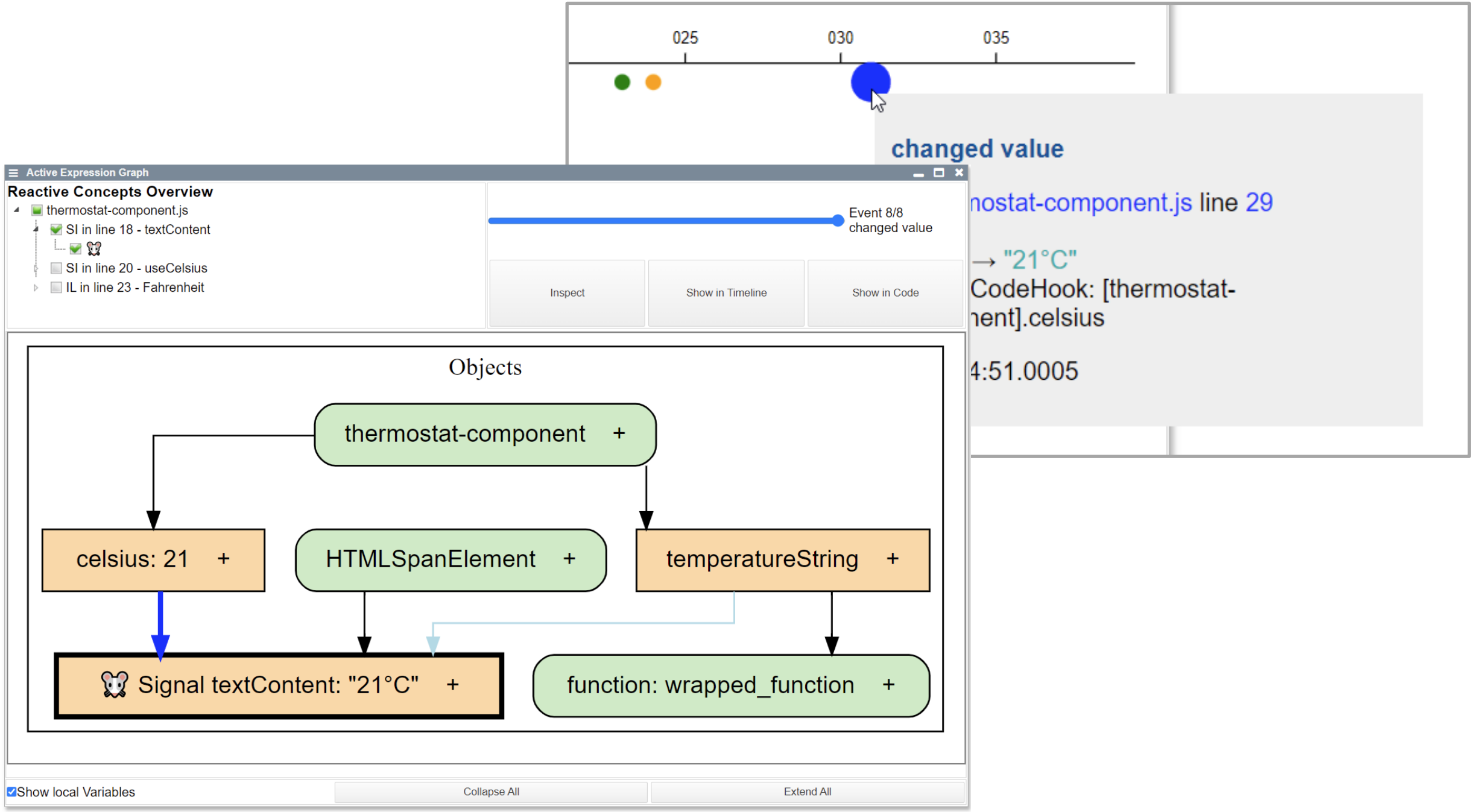
Reactive Concepts Overview

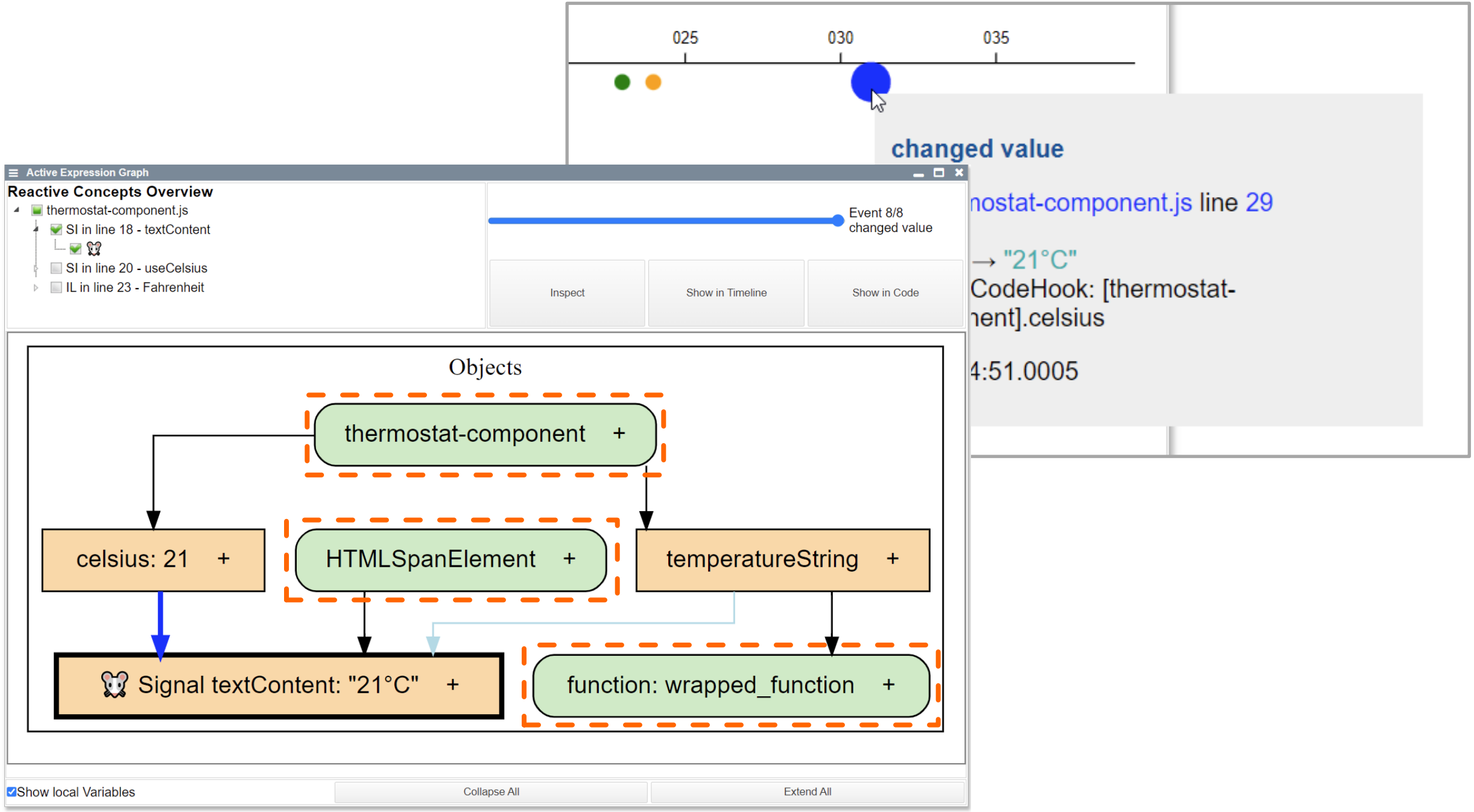
- thermostat-component.js
  - SI in line 18 - textContent
  - SI in line 20 - useCelsius
  - IL in line 23 - Fahrenheit

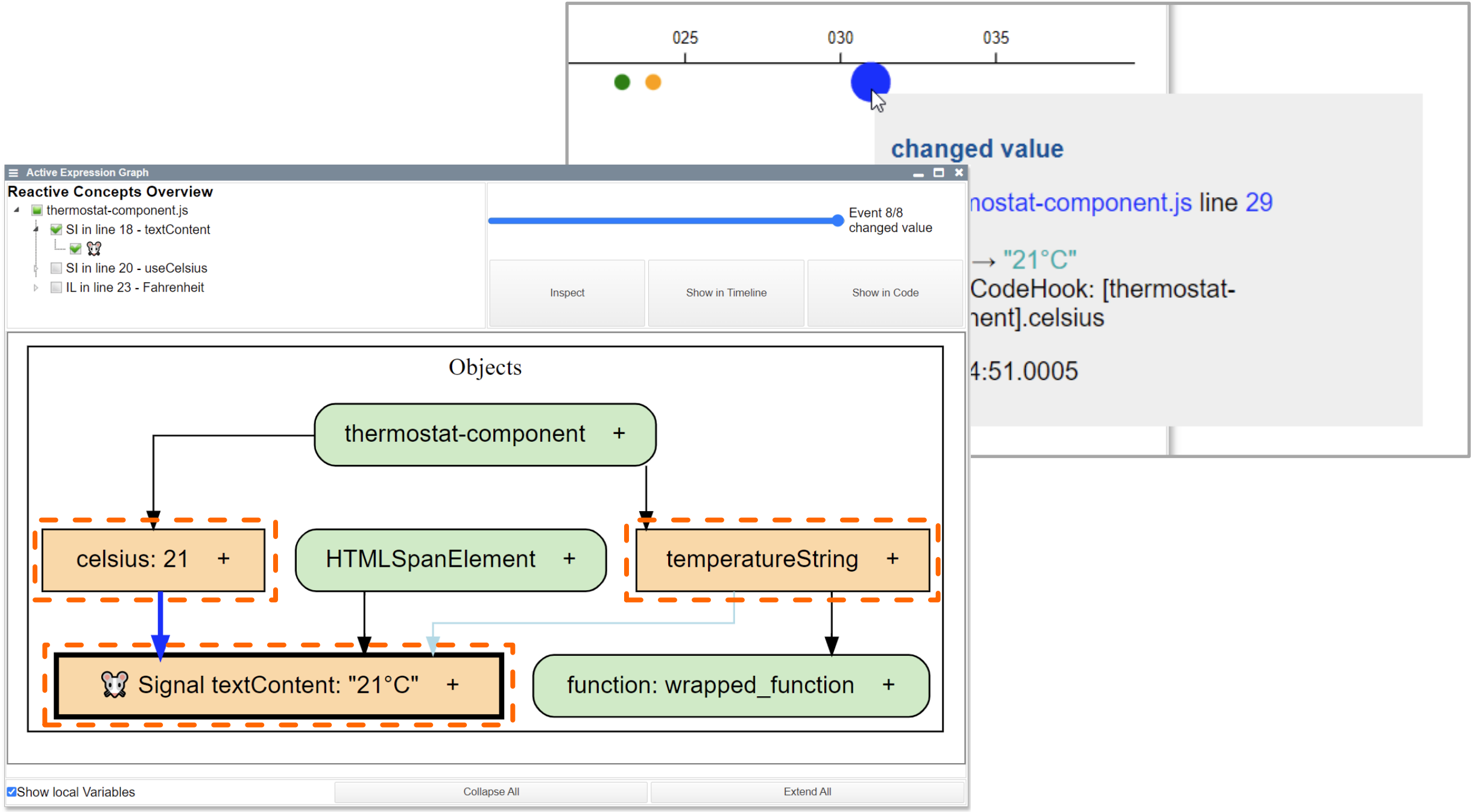
Timeline

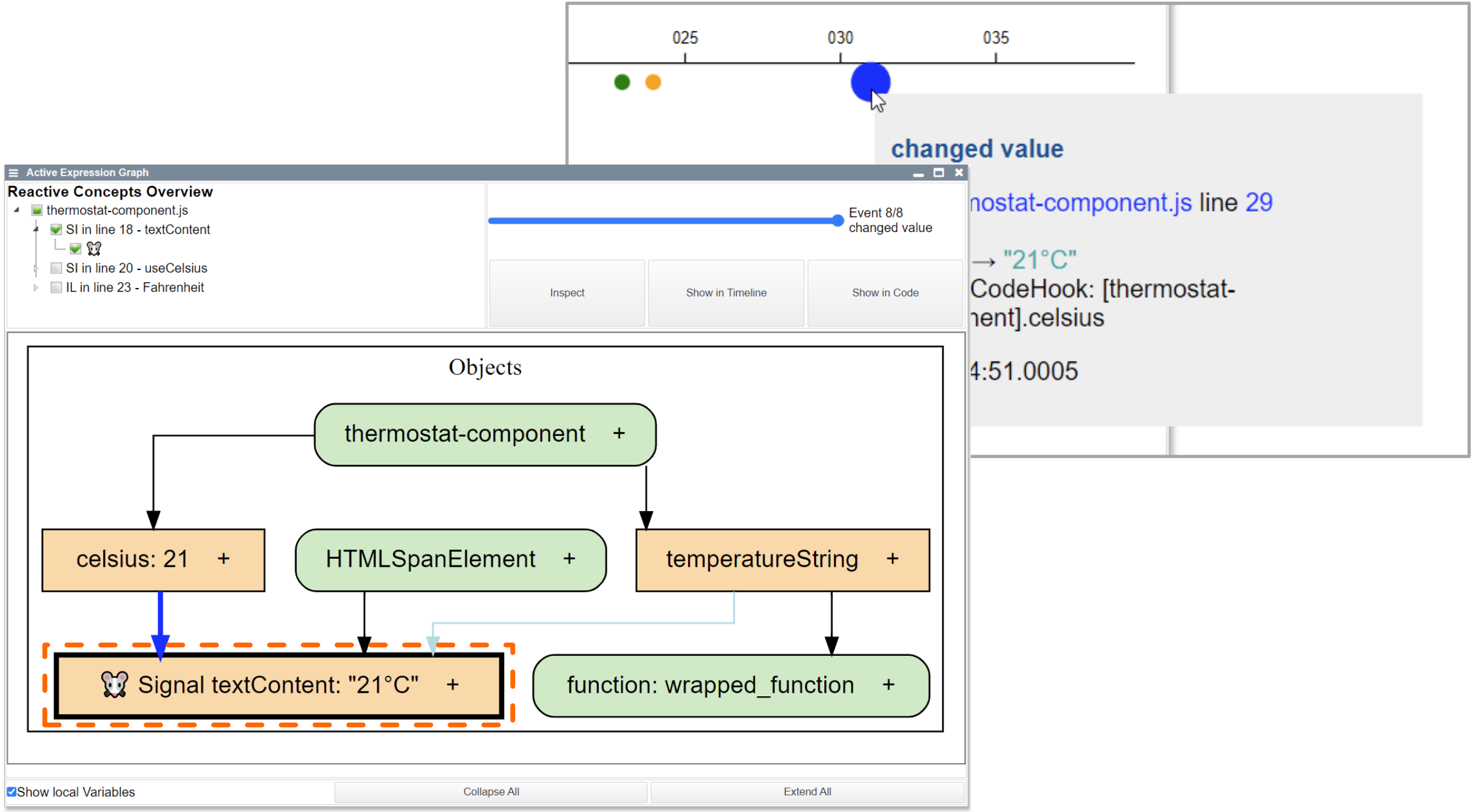


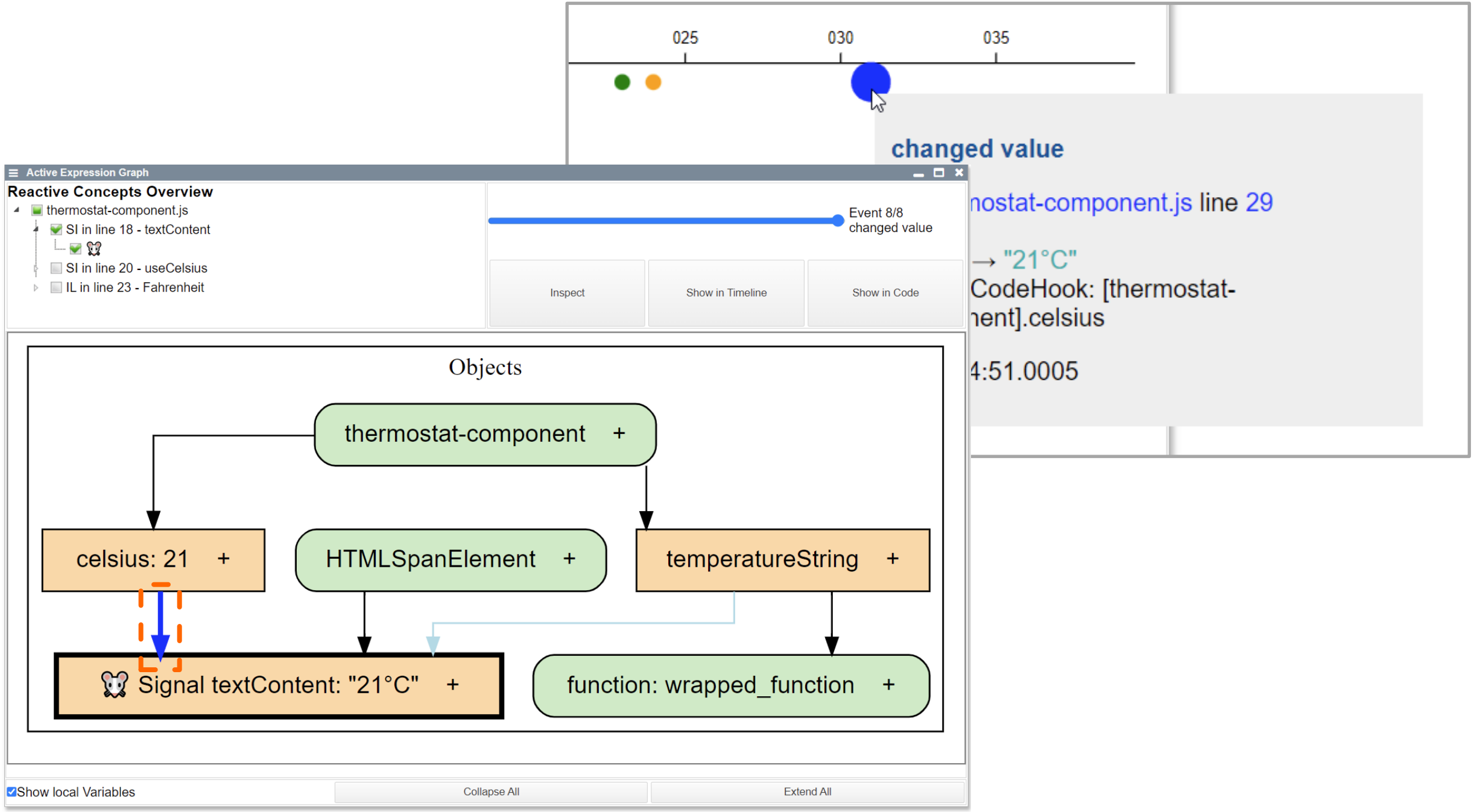
Thermostat
- 21°C +
Use Celsius
Active Expression Event Timeline
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
025
030
035
changed value
in thermostat-component.js line 29
"20°C" → "21°C"
SourceCodeHook: [thermostat-component].celsius
at 17:44:51.0005
Timeline
textContent (8)
01 AM
005
010
015
020
025
030
035
040
created
"20°C"
in thermostat-component.js line 18
at 17:37:26.0671

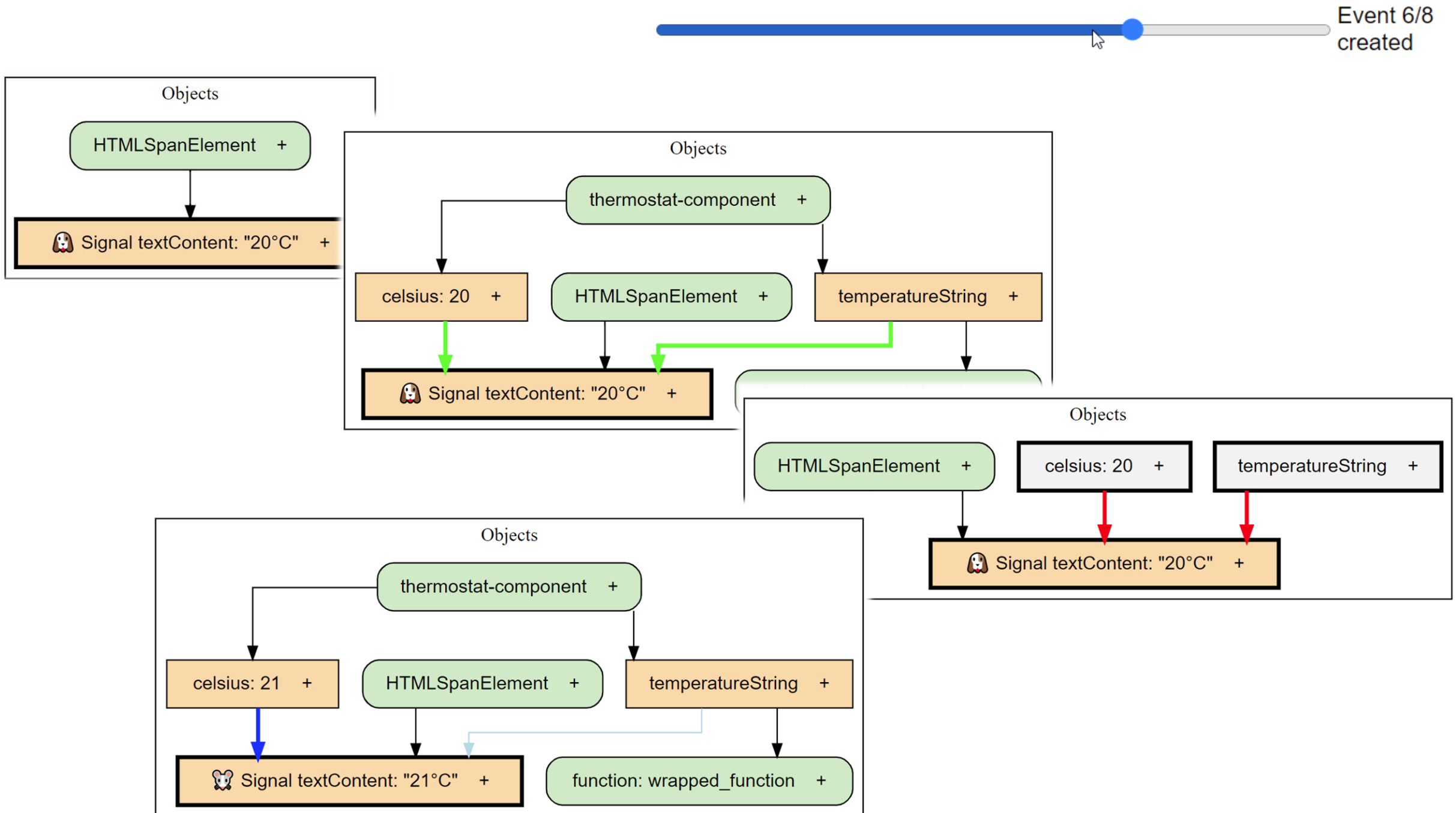

025
030
035
changed value
nostat-component.js line 29
→ "21°C"
CodeHook: [thermostat-
nent].celsius
4:51.0005
Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 8/8
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All

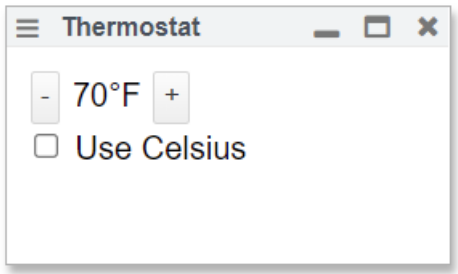

025
030
035
changed value
nostat-component.js line 29
→ "21°C"
CodeHook: [thermostat-
nent].celsius
4:51.0005
Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 8/8
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All

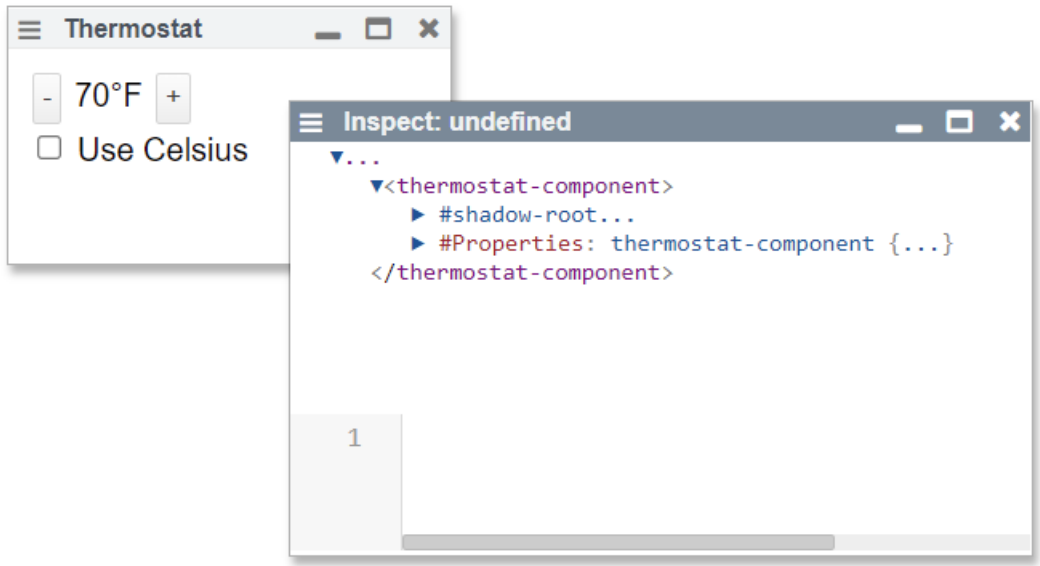

025
030
035
changed value
nostat-component.js line 29
→ "21°C"
CodeHook: [thermostat-
nent].celsius
4:51.0005
Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 8/8
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All


025
030
035
changed value
nostat-component.js line 29
→ "21°C"
CodeHook: [thermostat-
nent].celsius
4:51.0005
Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 8/8
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All

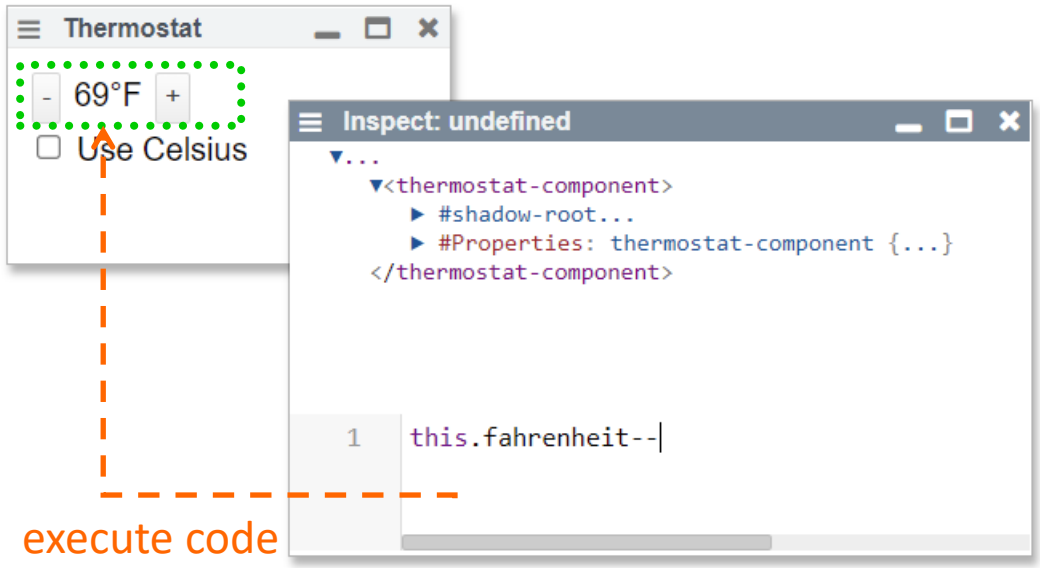

025
030
035
changed value
nostat-component.js line 29
→ "21°C"
CodeHook: [thermostat-
nent].celsius
4:51.0005
Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 8/8
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All


Event 6/8 created
Objects
HTMLSpanElement +
Signal textContent: "20°C" +
Objects
thermostat-component +
celsius: 20 +
HTMLSpanElement +
temperatureString +
Signal textContent: "20°C" +
Objects
HTMLSpanElement +
celsius: 20 +
temperatureString +
Signal textContent: "20°C" +
Objects
thermostat-component +
celsius: 21 +
HTMLSpanElement +
temperatureString +
Signal textContent: "21°C" +
function: wrapped_function +


Thermostat
-
70°F
+
Use Celsius

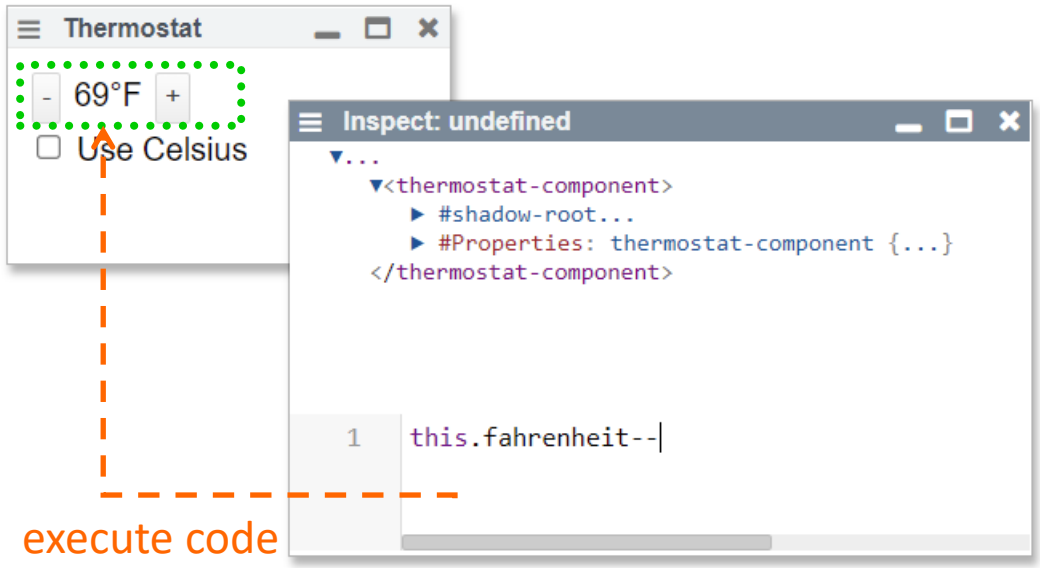

Thermostat
-
70°F
+
Use Celsius
Inspect: undefined
▼...
▼<thermostat-component>
▶ #shadow-root...
▶ #Properties: thermostat-component {...}
</thermostat-component>
1

updates

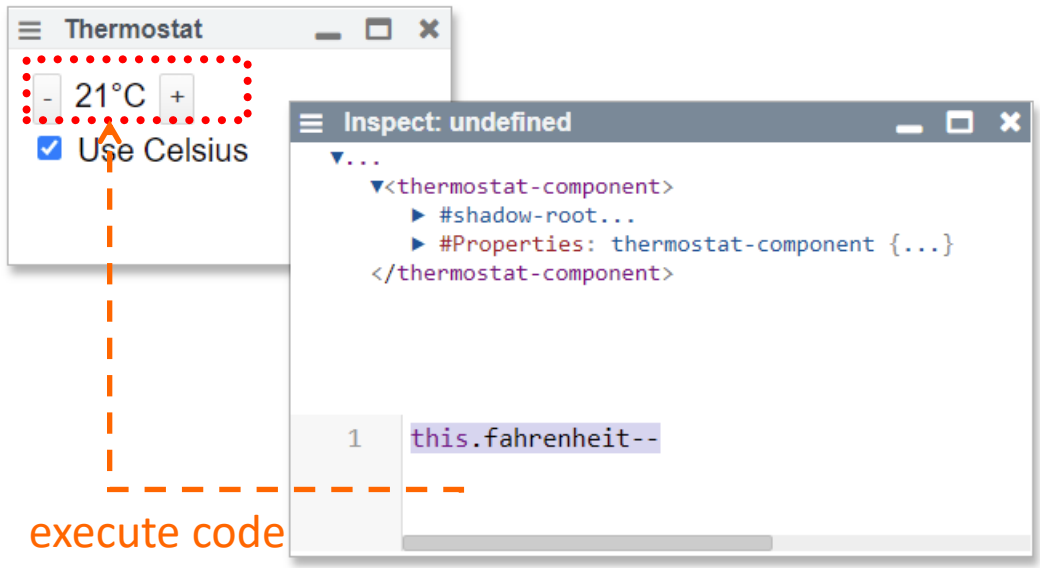


execute code

updates

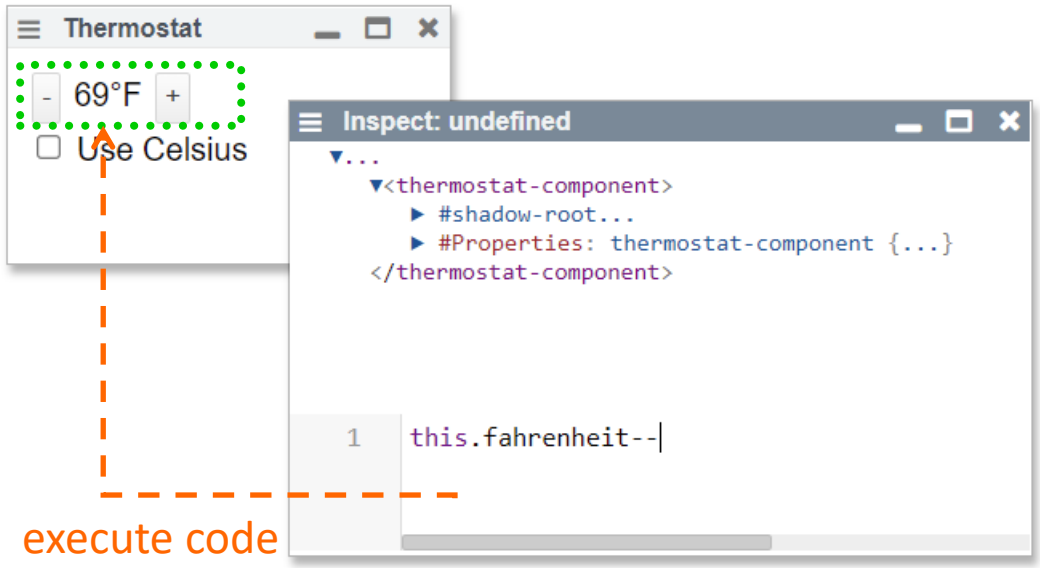


no effect!



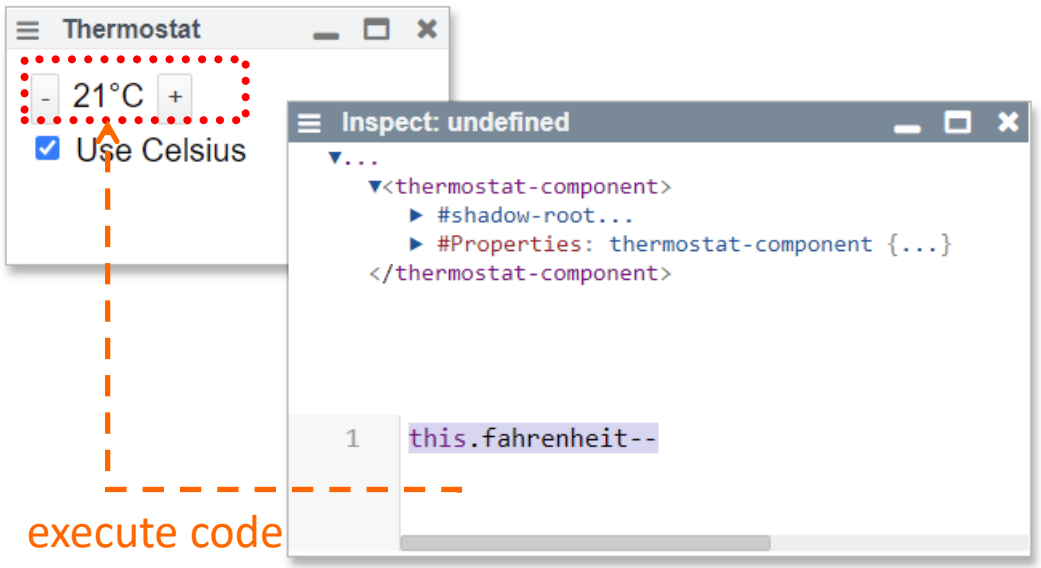
Bug!

updates



execute code

no effect!



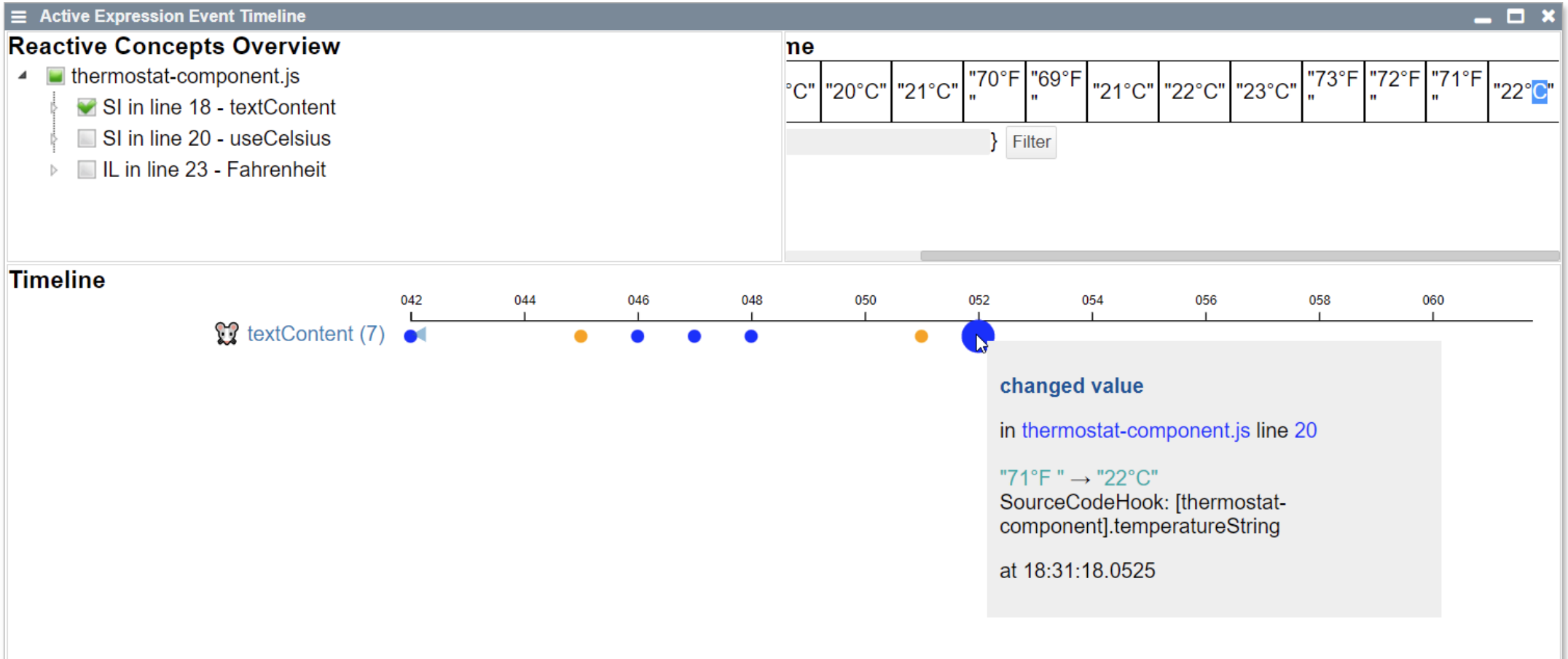
execute code

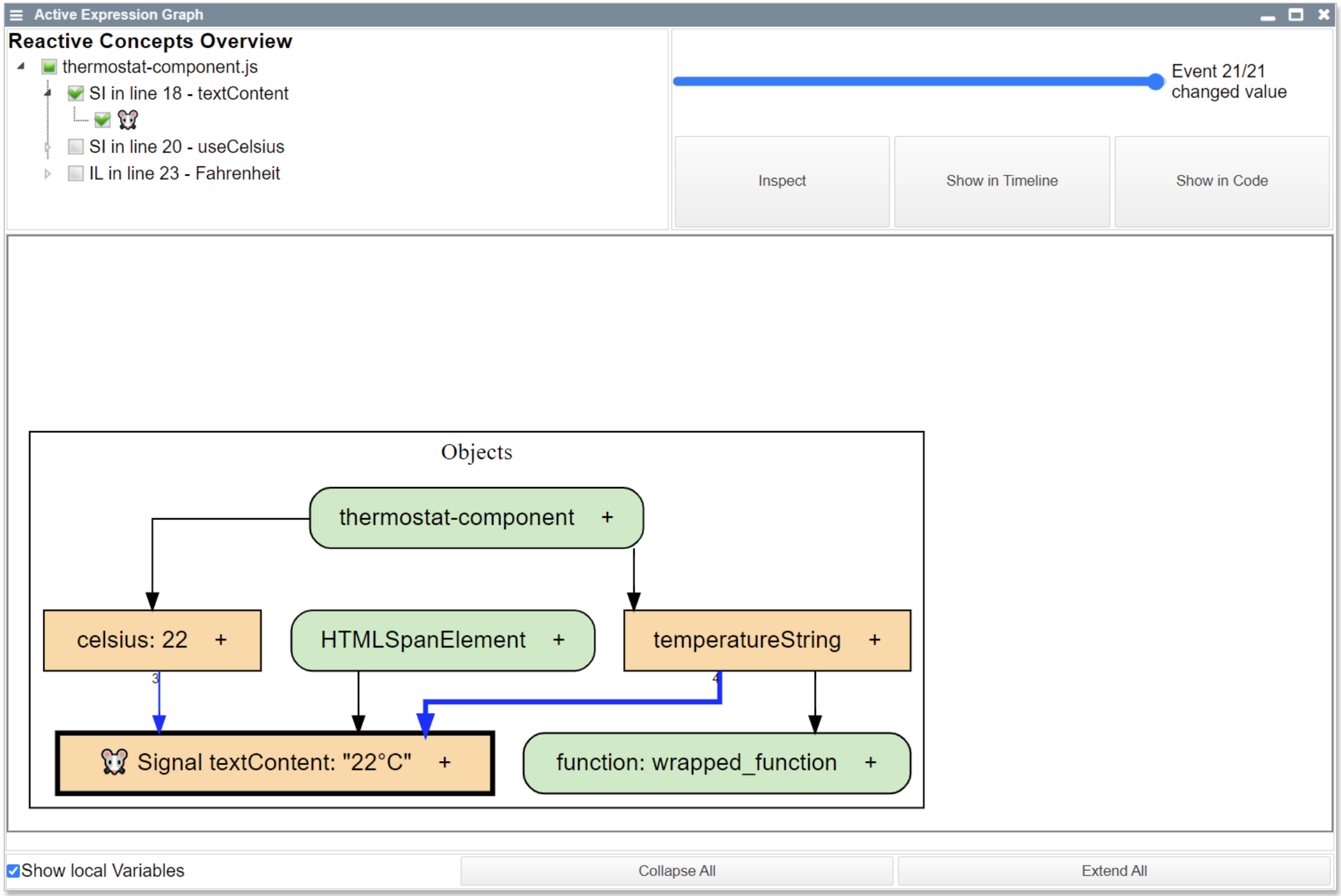
Infection Propagation

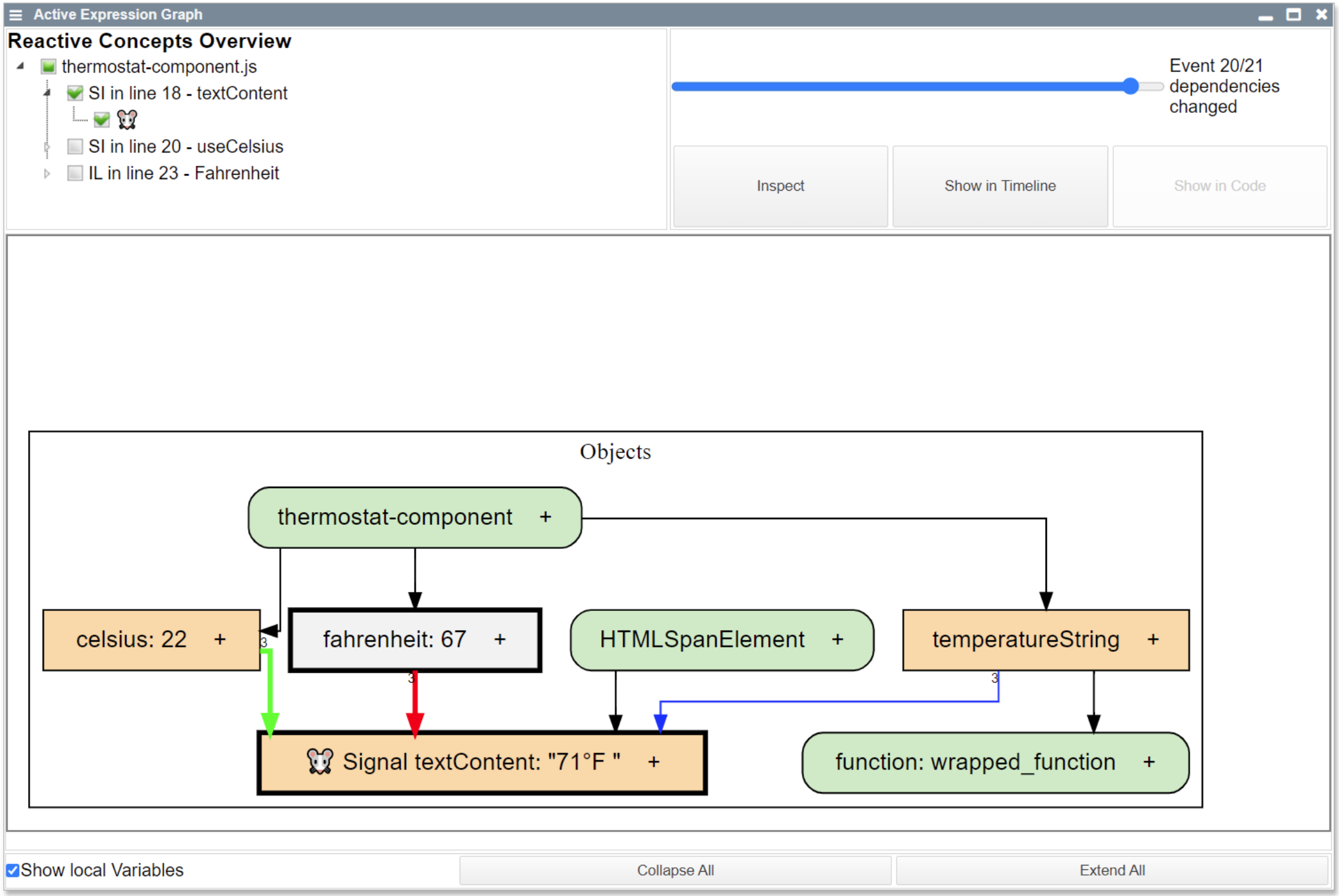
Expected Behavior: view update

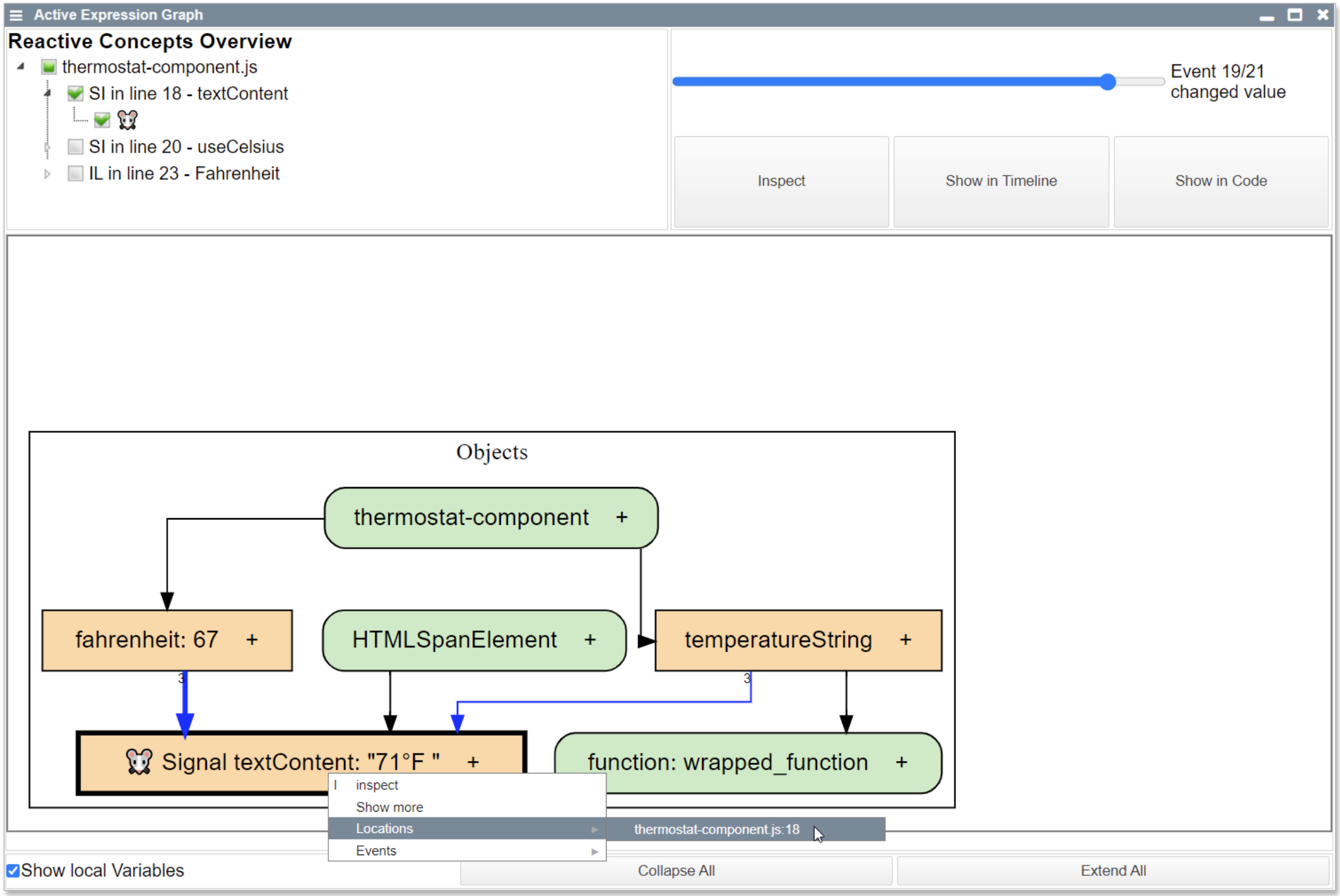
?

Failure: no update


Active Expression Event Timeline
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
ne
°C"
"20°C"
"21°C"
"70°F "
"69°F "
"21°C"
"22°C"
"23°C"
"73°F "
"72°F "
"71°F "
"22°C"
} Filter
Timeline
042
044
046
048
050
052
054
056
058
060
textContent (7)
changed value
in thermostat-component.js line 20
"71°F " → "22°C"
SourceCodeHook: [thermostat-component].temperatureString
at 18:31:18.0525


Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 21/21
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 22 +
HTMLSpanElement +
temperatureString +
3
4
Signal textContent: "22°C" +
function: wrapped_function +
Show local Variables
Collapse All
Extend All


Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 20/21 dependencies changed
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
celsius: 22 +
fahrenheit: 67 +
HTMLSpanElement +
temperatureString +
Signal textContent: "71°F " +
function: wrapped_function +
Show local Variables
Collapse All
Extend All


Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 19/21
changed value
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
fahrenheit: 67 +
HTMLSpanElement +
temperatureString +
Signal textContent: "71°F " +
function: wrapped_function +
inspect
Show more
Locations
Events
thermostat-component.js:18
Show local Variables
Collapse All
Extend All

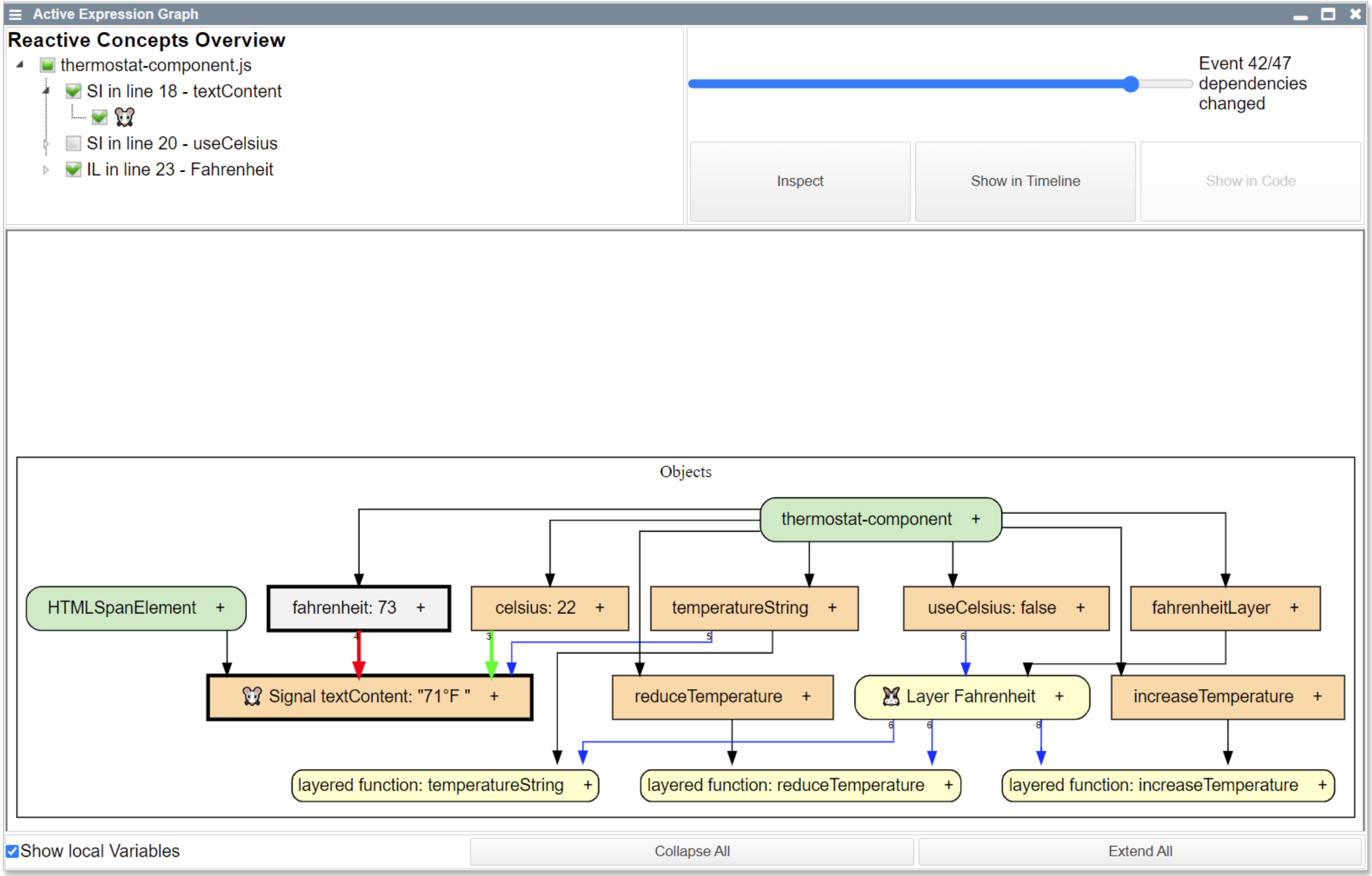
thermostat-component.js

https://lively-kernel.org/lively4/aexpr/src/client/reactive/components/rewritten/thermostat-component.js

```
14      });
15      this.reduce.addEventListener("click", () => {
16        this.reduceTemperature();
17      });
18  SI  always: this.temperature.textContent = this.temperatureString();
19
20  RE  always: this.useCelsius = this.celsiusMode.checked;
21      this.setupLayer();
22
23  IL  this.fahrenheitLayer.activeWhile(() => !this.useCelsius);
24
25      this.replaceMigratableAEs();
```

```
40    setupLayer() {
41      this.fahrenheitLayer = new Layer("Fahrenheit");
42      this.fahrenheitLayer.refineObject(this, {
43        increaseTemperature() {
44          this.fahrenheit++;
45        },
46        reduceTemperature() {
47          this.fahrenheit--;
48        },
49        temperatureString() {
50          return this.fahrenheit + "°F ";
51        }
52      });
```

```
54      this.fahrenheitLayer.onActivate(() => {
55        lively.notify('use °F')
56        this.fahrenheit = Math.round(this.celsius * 9 / 5 + 32);
57      });
58      this.fahrenheitLayer.onDeactivate(() => {
59        lively.notify('use °C')
60        this.celsius = Math.round((this.fahrenheit - 32) / 9 * 5);
61      });
62    }
```


Active Expression Graph
Reactive Concepts Overview
thermostat-component.js
SI in line 18 - textContent
SI in line 20 - useCelsius
IL in line 23 - Fahrenheit
Event 42/47 dependencies changed
Inspect
Show in Timeline
Show in Code
Objects
thermostat-component +
HTMLSpanElement +
fahrenheit: 73 +
celsius: 22 +
temperatureString +
useCelsius: false +
fahrenheitLayer +
Signal textContent: "71°F " +
reduceTemperature +
Layer Fahrenheit +
increaseTemperature +
layered function: temperatureString +
layered function: reduceTemperature +
layered function: increaseTemperature +
Show local Variables
Collapse All
Extend All

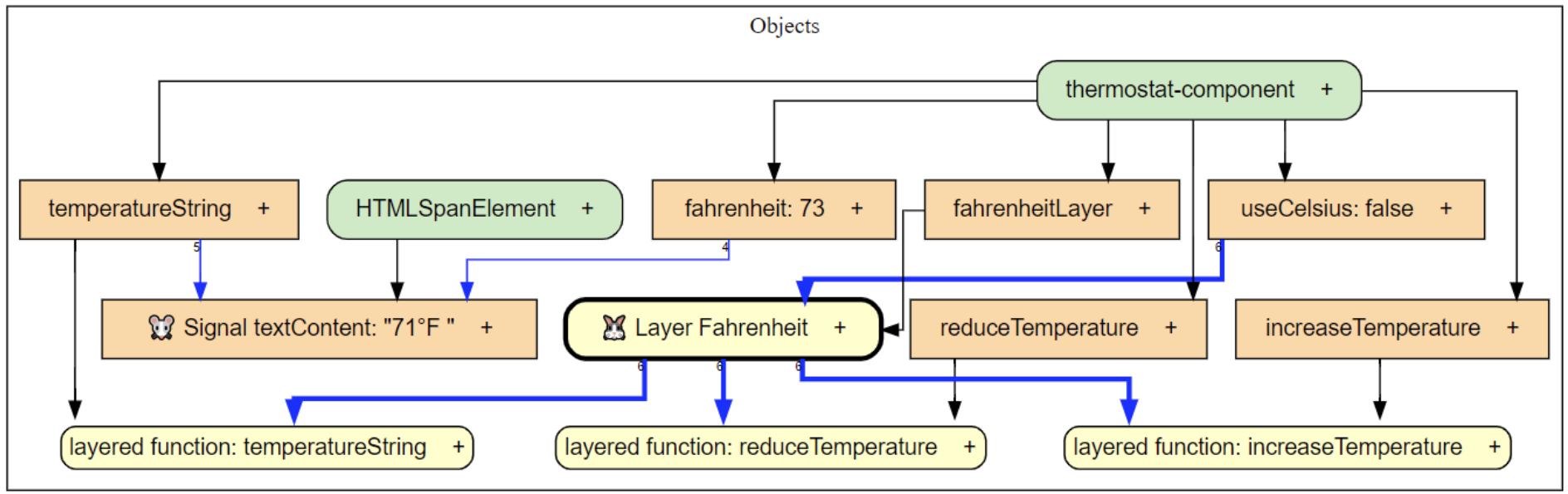
Active Expression Graph

Reactive Concepts Overview

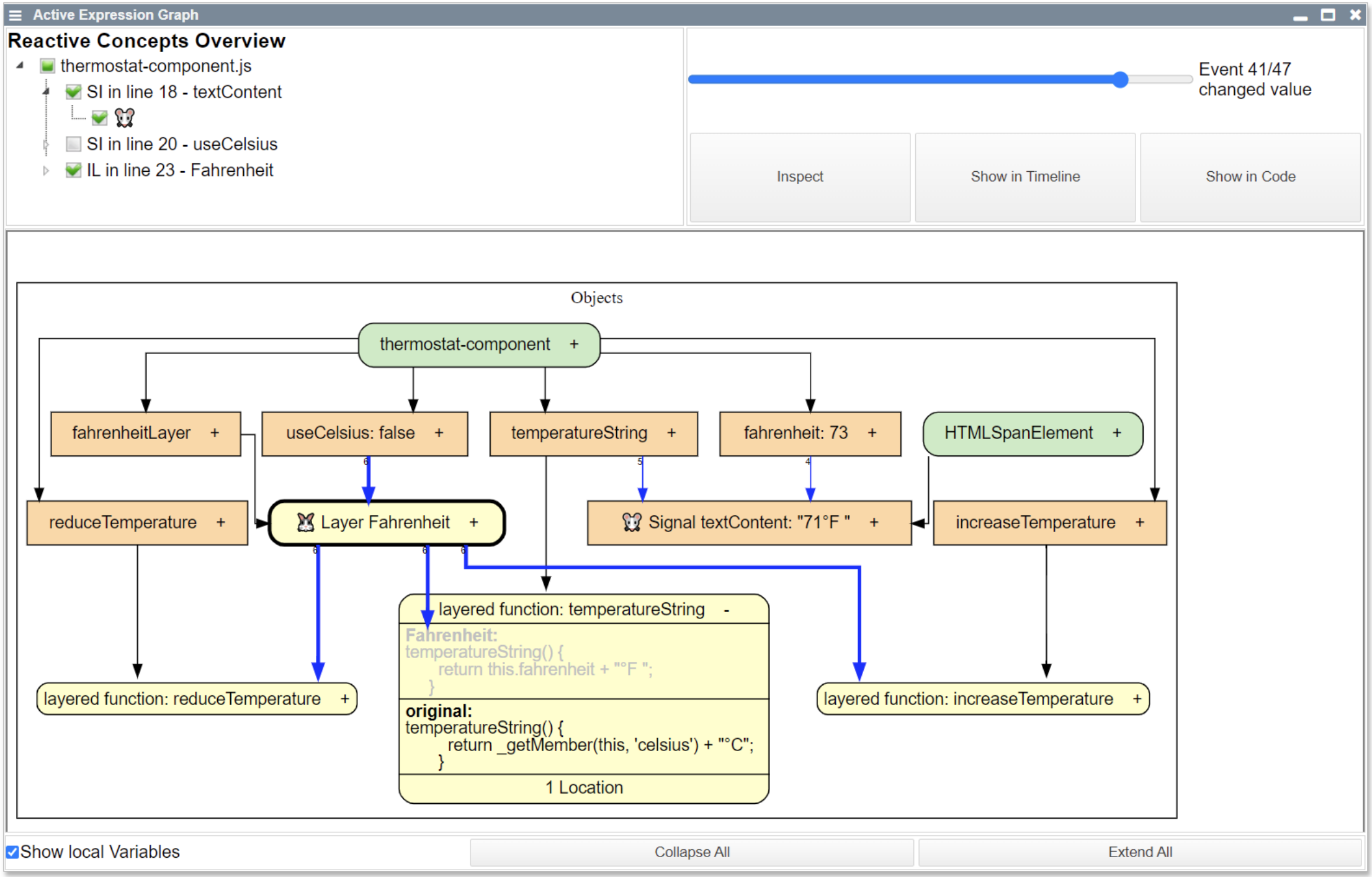
- thermostat-component.js
  - SI in line 18 - textContent
    - 🐭
  - SI in line 20 - useCelsius
  - IL in line 23 - Fahrenheit

Event 41/47 changed value

Inspect | Show in Timeline | Show in Code



Show local Variables | Collapse All | Extend All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Event 41/47
changed value
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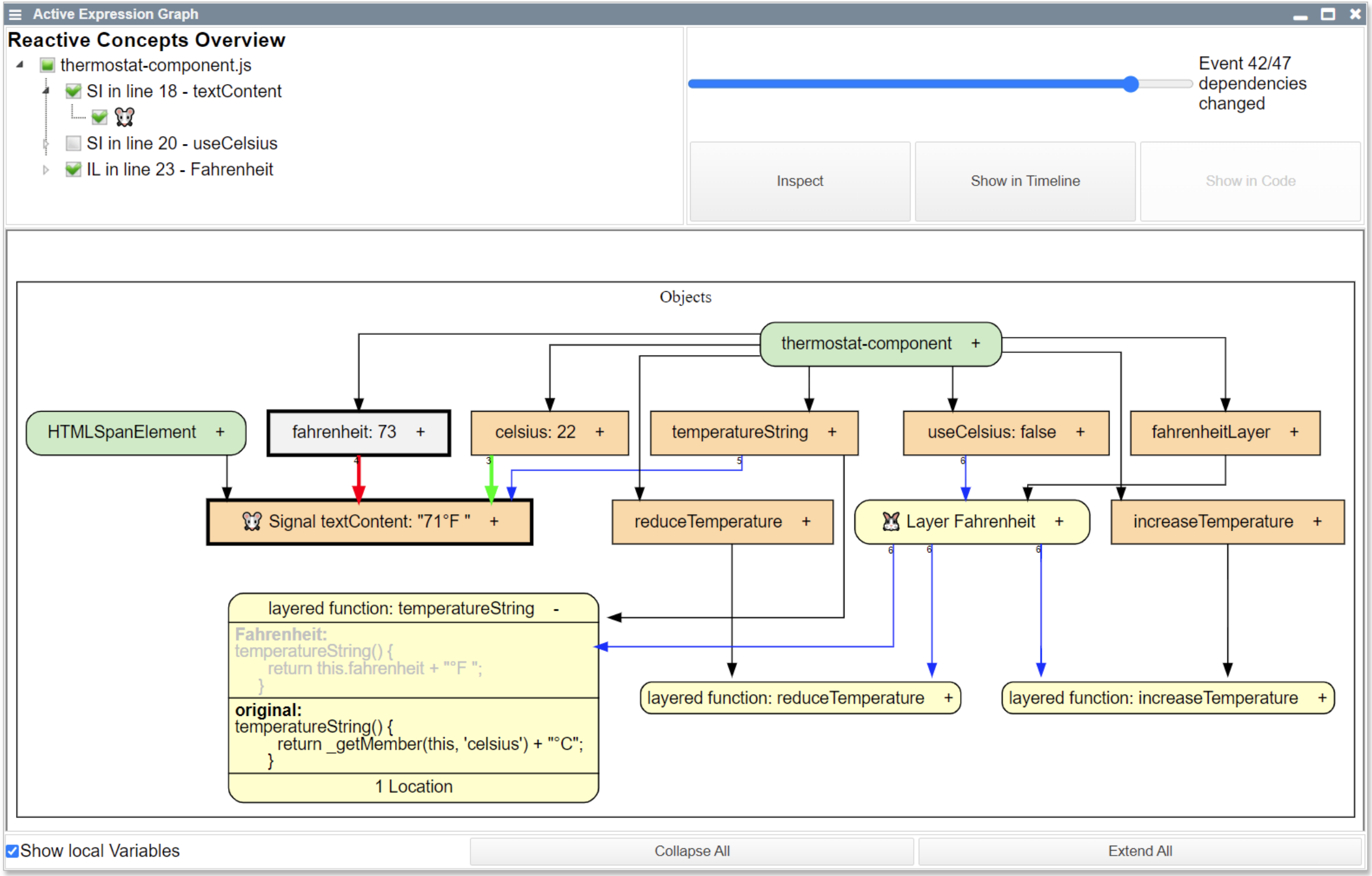
reduceTemperature +
Layer Fahrenheit +
Signal textContent: "71°F " +
increaseTemperature +
layered function: temperatureString -
Fahrenheit:
temperatureString() {
return this.fahrenheit + "°F ";
}
original:
temperatureString() {
return _getMember(this, 'celsius') + "°C";
}
1 Location
layered function: reduceTemperature +
layered function: increaseTemperature +
Show local Variables
Collapse All
Extend All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original:
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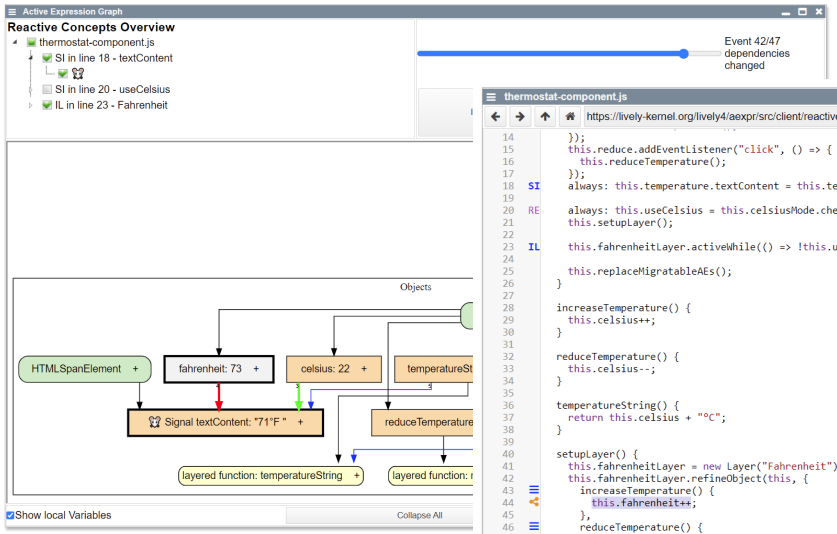
return _getMember(this, 'celsius') + "°C";
}
1 Location
layered function: reduceTemperature +
layered function: increaseTemperature +
Show local Variables
Collapse All
Extend All

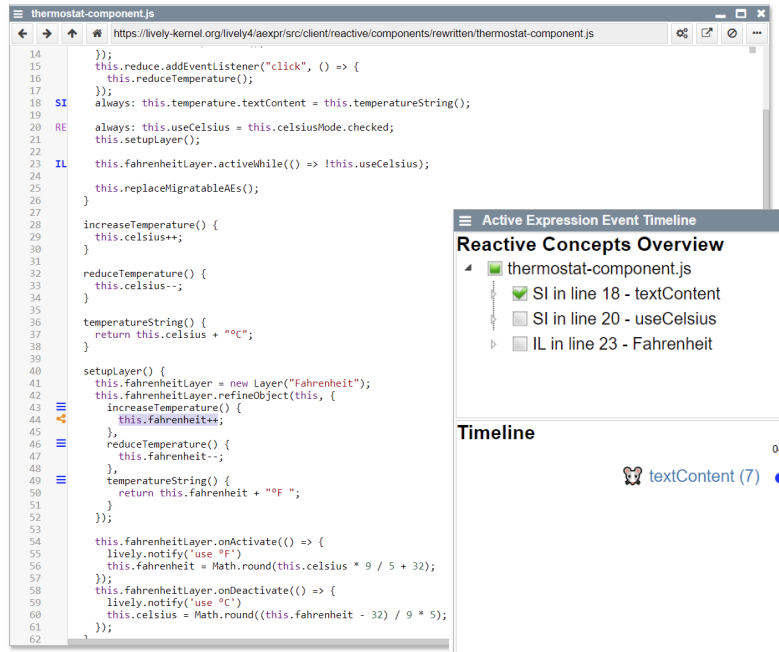
Fix Bug by Introducing a Constraint

```
always: this.fahrenheit = Math.round(this.celsius * 9 / 5 + 32)
always: this.celsius = Math.round((this.fahrenheit - 32) / 9 * 5)
```

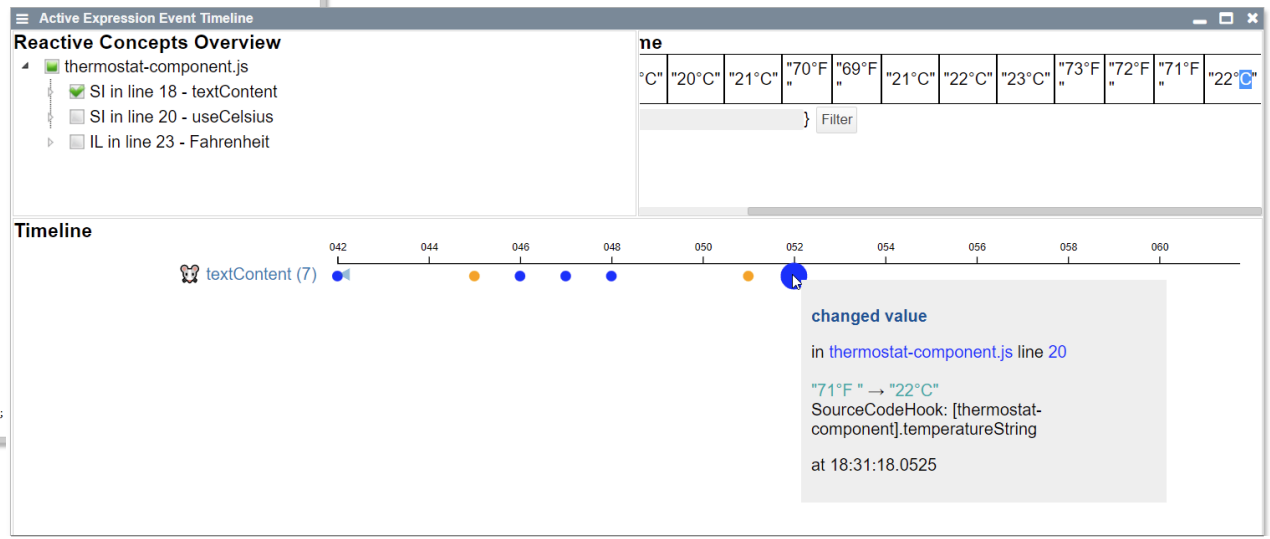
Active Expression Tool Framework with ILA support



GraphView

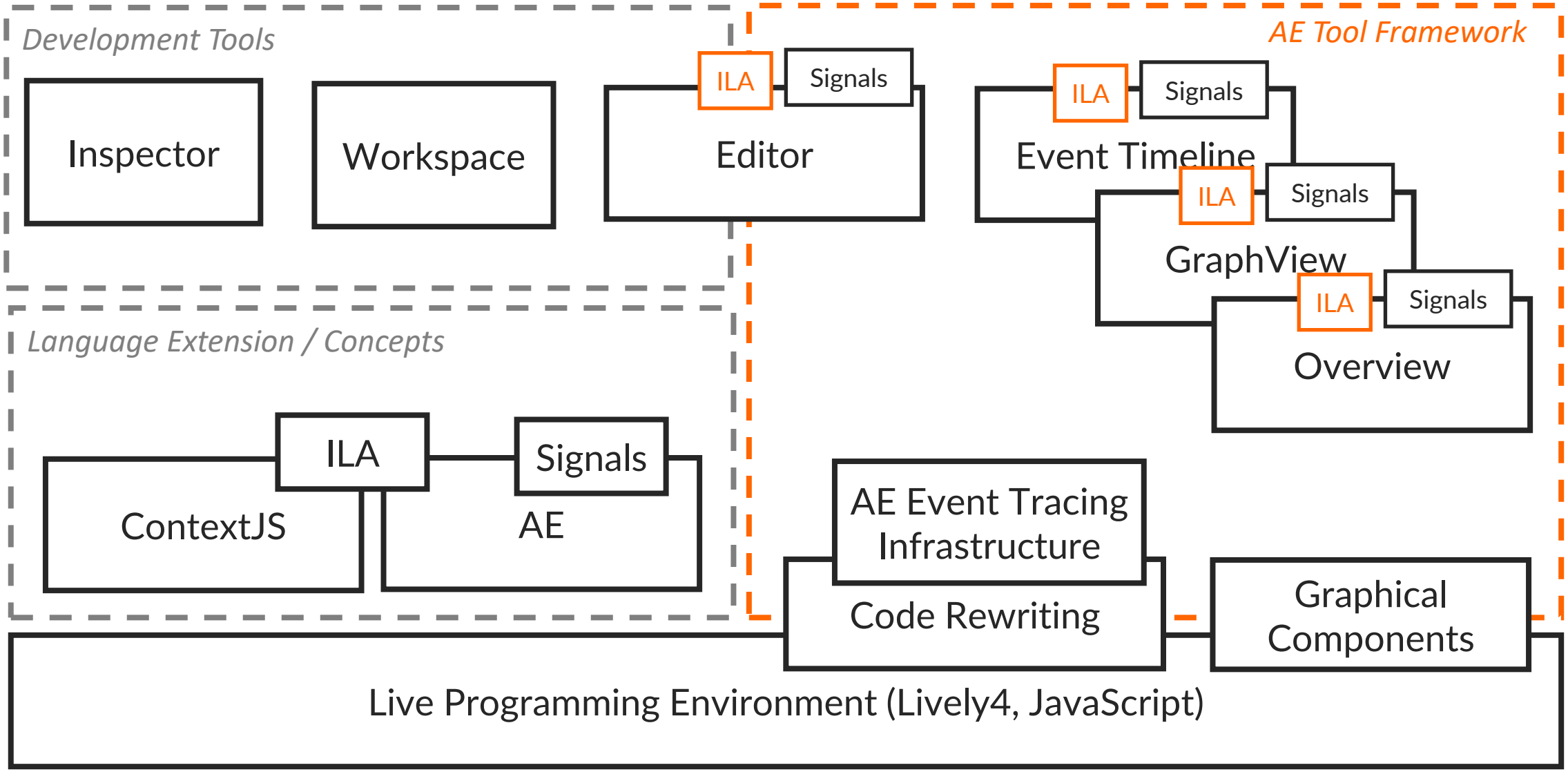


Code Annotations



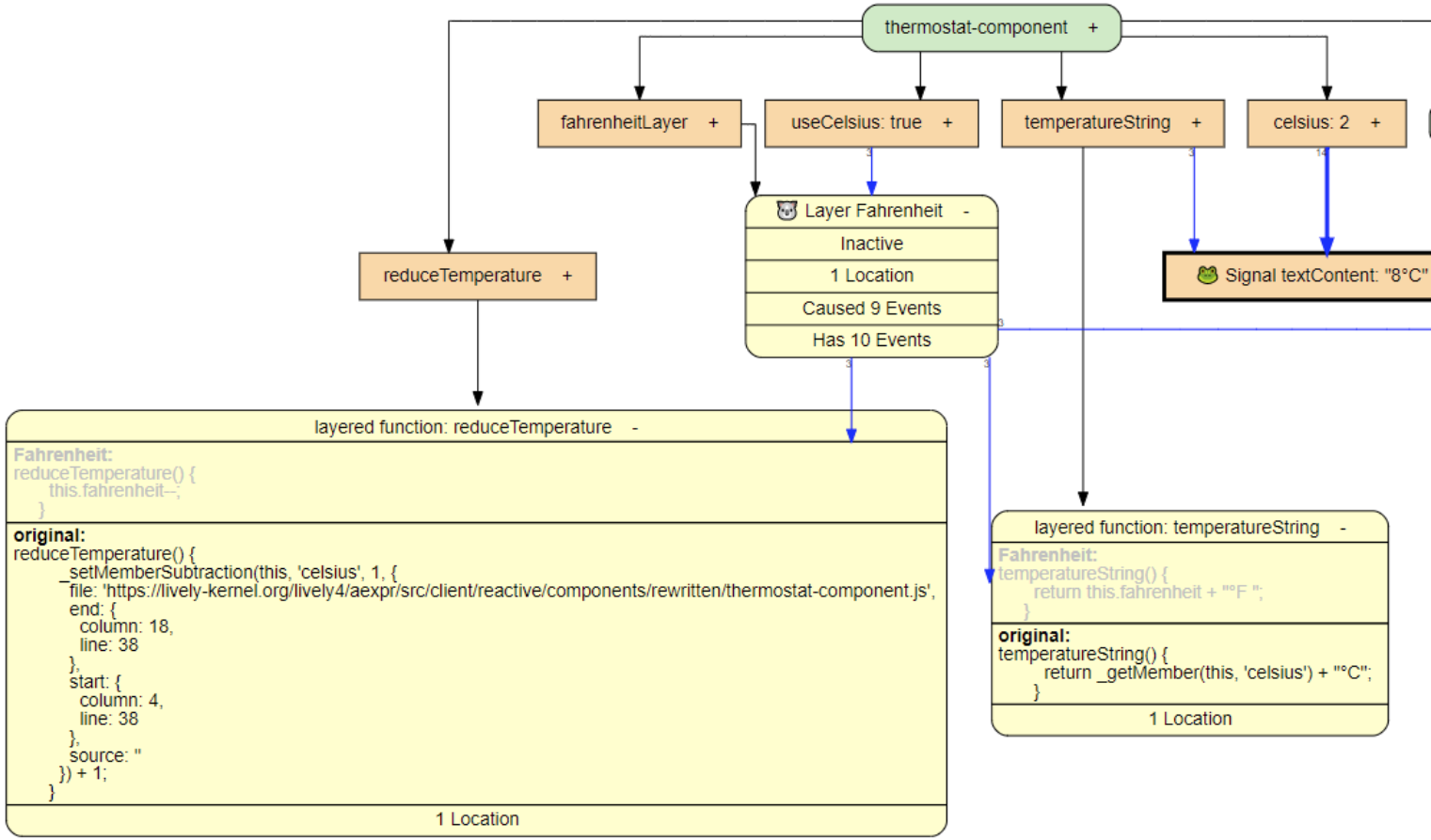
Event Timeline

Implementation



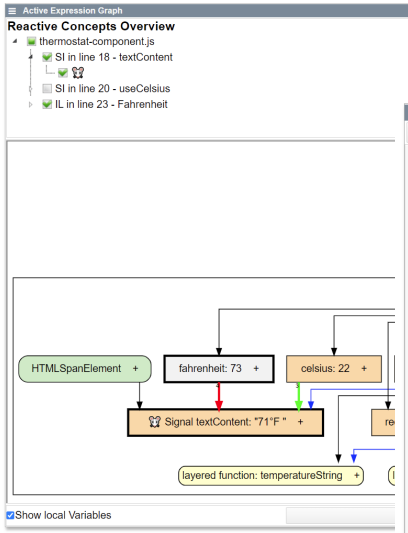
Future Work

- Live programming and Active Expressions
- Leaking abstractions
- Stable layout

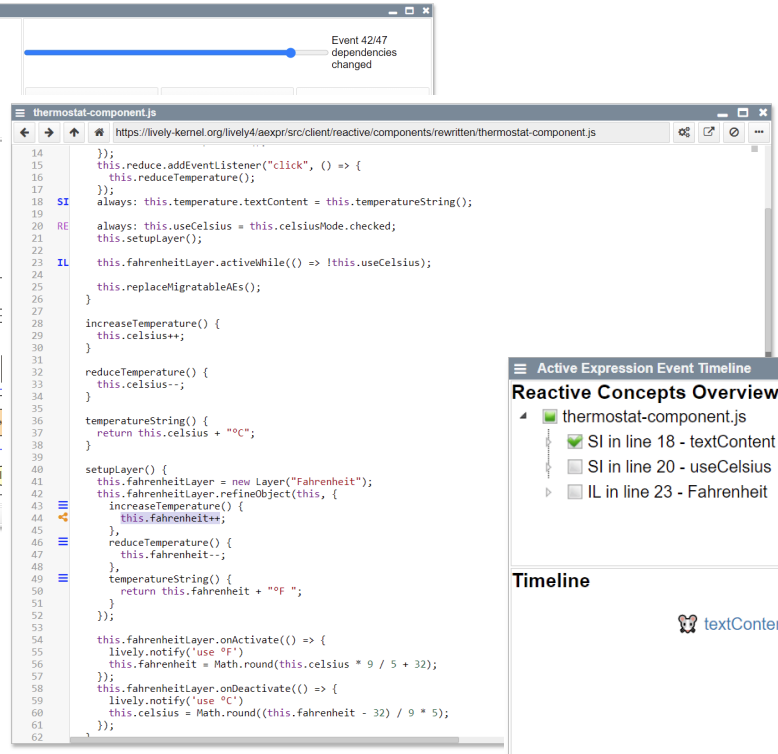


Explicit Tool Support for Implicit Layer Activation

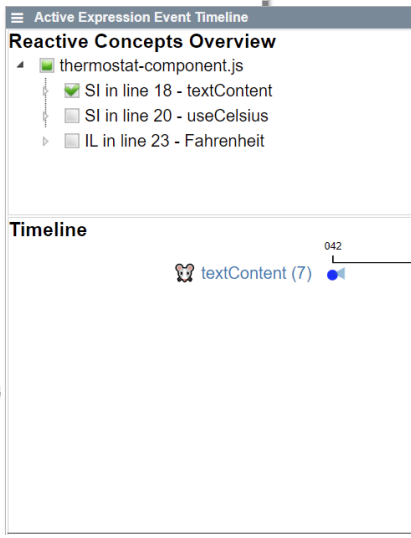
- **Problem:** Missing tool support for implicit layer activation (ILA)
- **Approach:** Extend and adapt shared tool framework based on Active Expressions
- **Impact:** Explore and debug systems built with concepts from COP and reactive programming



GraphView



Code Annotations



Event Timeline