State of state-machines in front-end

Jiayi Hu – Front-end developer

{codemotion}
Online Tech Conference
- Italian edition -

24-25-26 Novembre, 2020

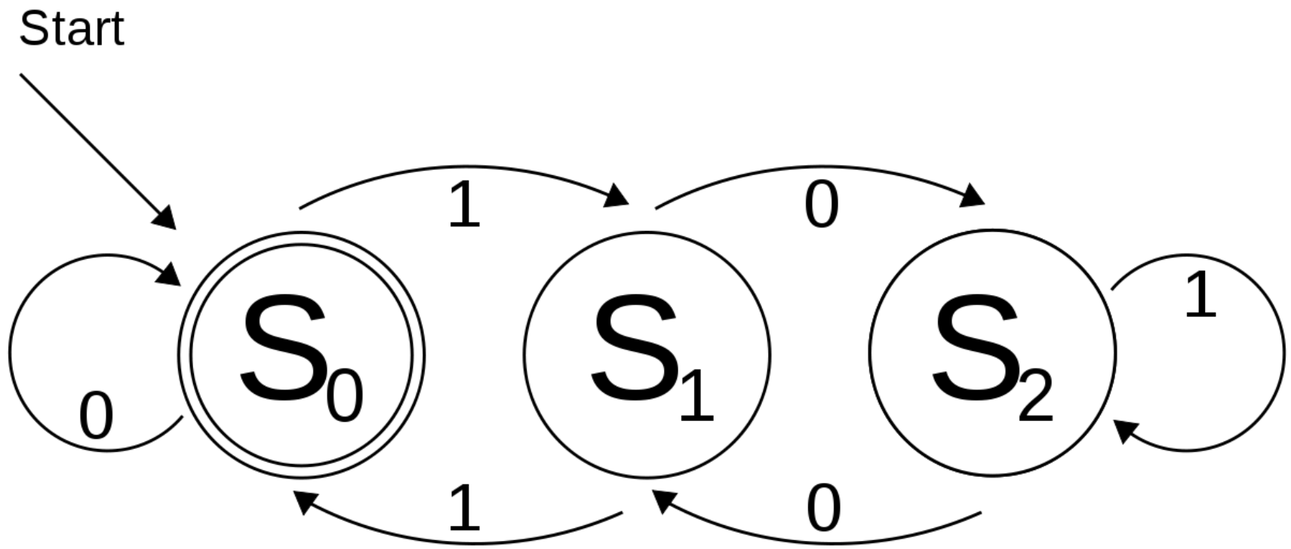
Schedule of this talk

1. Introduction to State machines
2. State machines in JavaScript
3. State machines in TypeScript
4. State machines in Redux
5. State machines in xstate

Introduction to state machines

$$(\Sigma, S, s_0, \delta, F)$$

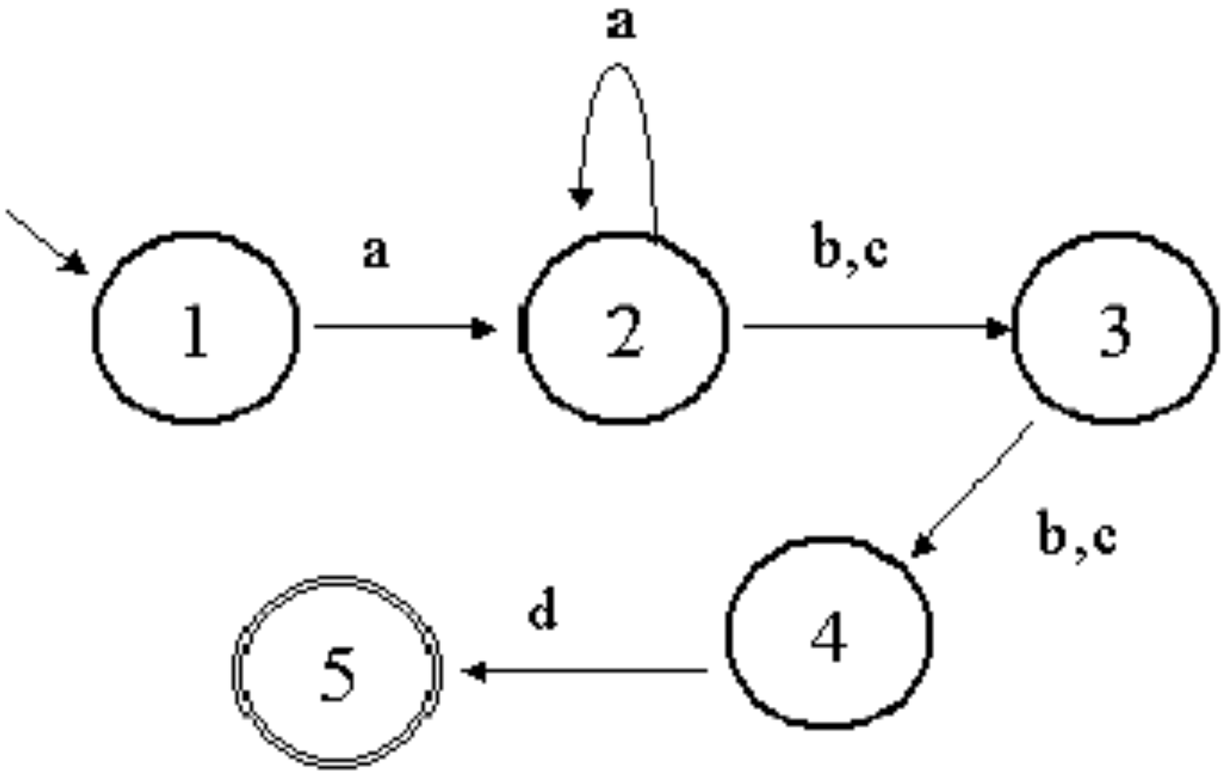
- Σ the input symbols
- S the set of states
- s_0 the initial state
- δ the state transition function $\delta : S \times \Sigma \to S$
- F the final state, possibly empty



Regex

`a+[bc]2d`

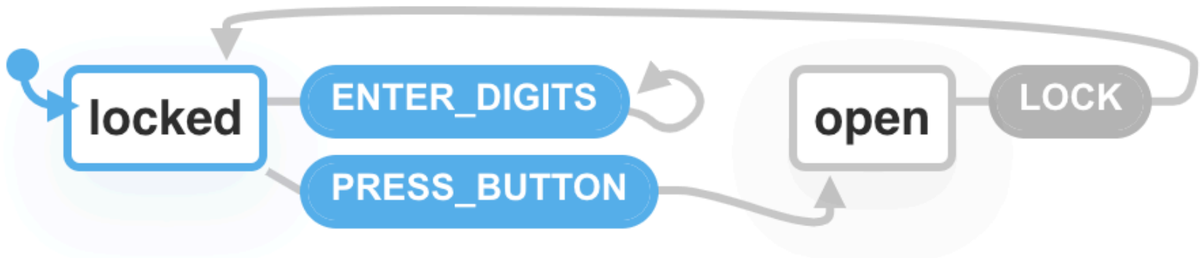
- $\Sigma = \{a, b, c, d\}$
- $S = \{1, 2, 3, 4, 5\}$
- $s_0 = 1$ the initial state
- δ
- $F = 5$



Lock

$\Sigma = \{\text{ENTER\_INVALID}, \text{ENTER\_CORRECT}, \text{TIMEOUT}\}$

- $S = \{locked, open\}$
- $s_0 = locked$ the initial state
- $\delta =$ `function transition(state: S, symbol: Sigma): S`
- $F = \emptyset$



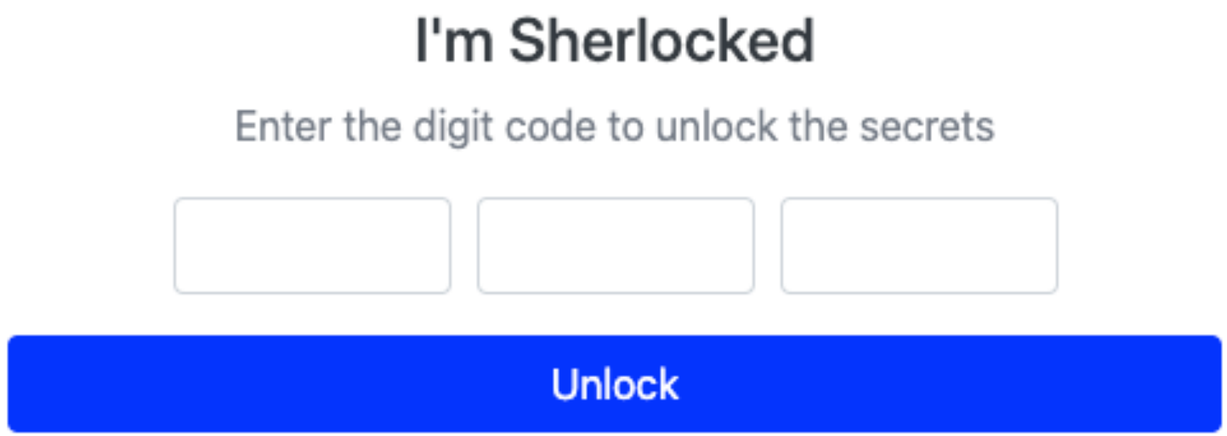
Every Component is actually an *implicit state machine*

```
class StateMachine {
  constructor(code) {
    this.state = "LOCKED";
    this.code = code;
    this.digits = "";
  }

  enterDigits(digits) {
    this.digits = digits;
  }

  pressButton() {
    if (this.digits === this.code) {
      this.state = "OPEN";
      this.digits = "";
    }

    this.digits = "";
  }

  lock() {
    this.state = "LOCKED";
    this.digits = "";
  }
}
```

```
const lock = new StateMachine('000')
lock.pressButton()
console.log(lock.state) // 'LOCKED'
lock.enterDigits('0')
lock.enterDigits('00')
lock.enterDigits('000')
lock.pressButton()
console.log(lock.state) // 'OPEN'
lock.lock()
console.log(lock.state) // 'LOCKED'
```

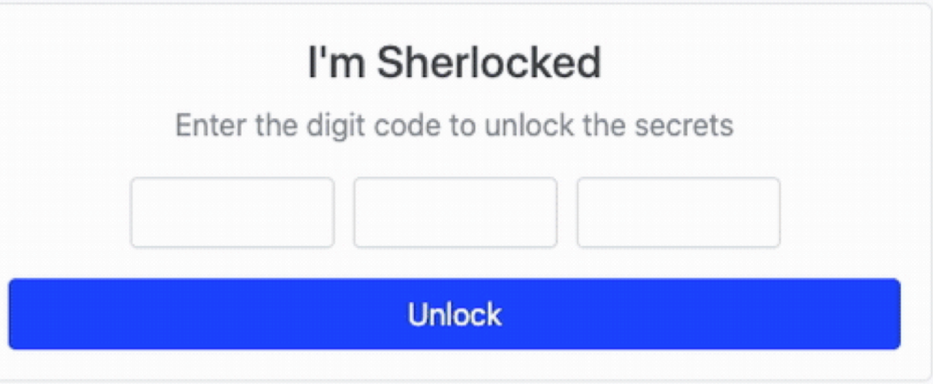
Attempt: Class state [1]

```
const [state, setState] =
  React.useState(new StateMachine('000'));

const handleChange = (value) => {
  state.enterDigits(value);
  setState(state);
};

const handleSubmit = (event) => {
  event.preventDefault();
  state.pressButton();
  setState(state);
};

const handleLock = () => {
  state.lock();
  setState(state);
};
```



[1] https://codesandbox.io/s/lock-qzkyp?file=/src/Lock1.jsx

```
import "./styles.scss";
import useDigitInput from "react-digit-input";

class StateMachine {
  constructor(code) {
    this.state = "LOCKED";
    this.code = code;
    this.digits = "";
  }

  enterDigits(digits) {
    this.digits = digits;
  }

  pressButton() {
    if (this.digits === this.code) {
      this.state = "OPEN";
      this.digits = "";
    }

    this.digits = "";
  }

  lock() {
    this.state = "LOCKED";
    this.digits = "";
  }
}

const CODE = "000";

export default function Lock1() {
  const [state, setState] = React.useState(new StateMachine(CODE));
```



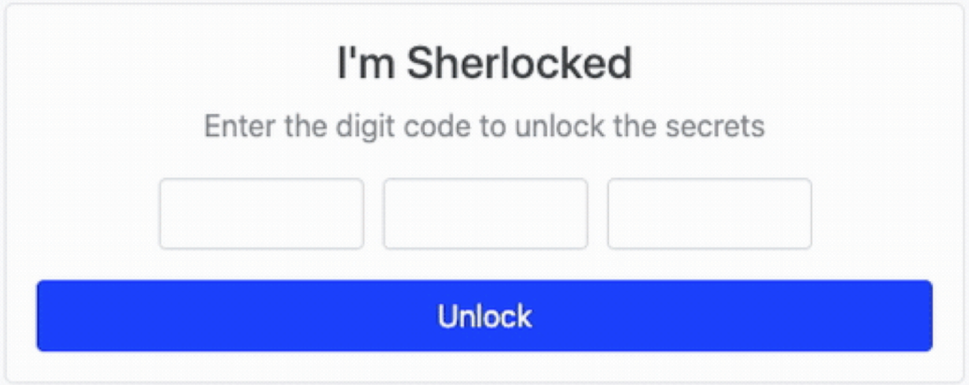
Attempt: POJO state [2]

```
const stateMachine = {
  state: "LOCKED",
  code: CODE,
  digits: ""
};

function enterDigits(stateMachine, digits) {
  return {
    ...stateMachine,
    digits
  };
}
```

[2] https://codesandbox.io/s/lock-qzkyp?file=/src/Lock2.jsx

```
function pressButton(stateMachine) {
  if (stateMachine.digits === stateMachine.code) {
    return {
      state: "OPEN",
      code: stateMachine.code,
      digits: ""
    };
  }

  return {
    ...stateMachine,
    digits: ""
  };
}

function lock(stateMachine) {
  return {
    state: "LOCKED",
    code: stateMachine.code,
    digits: ""
  };
}
```

```
  code: CODE,
  digits: ""
};

function enterDigits(stateMachine, digits) {
  return {
    ...stateMachine,
    digits
  };
}

function pressButton(stateMachine) {
  if (stateMachine.digits === stateMachine.code) {
    return {
      state: "OPEN",
      code: stateMachine.code,
      digits: ""
    };
  }

  return {
    ...stateMachine,
    digits: ""
  };
}

function lock(stateMachine) {
  return {
    state: "LOCKED",
    code: stateMachine.code,
    digits: ""
  };
}
```



Fallacy

```
const stateMachine = {
  state: 'OPEN',
  code: '000',
  digits: '' // ?
}

pressButton(stateMachine) // ?
```

Attempt 3

```
function transition(stateMachine, action) {
  switch (action.type) {
    case "ENTER_DIGITS":
      return {
        ...stateMachine,
        digits: action.payload
      };
    case "PRESS_BUTTON":
      if (stateMachine.digits === stateMachine.code) {
        return {
          state: "OPEN",
          code: stateMachine.code,
          digits: ""
        };
      }

      return {
        ...stateMachine,
        digits: ""
      };
    case "LOCK":
      return {
        state: "LOCKED",
        code: stateMachine.code,
        digits: ""
      };
    default:
      return stateMachine;
  }
}
```

Attempt: State [3]

```
type Locked = {
  state: 'LOCKED',
  code: string,
  digits: string
}
type Open = {
  state: 'OPEN',
  code: string
}

type StateMachine = Locked | Open
```

[3] https://codesandbox.io/s/lock-ts-gt2zn?file=/src/Lock3.tsx

Attempt: Action

```
type EnterDigits = {
  type: 'ENTER_DIGITS',
  payload: string
}
type PressButton = {
  type: 'PRESS_BUTTON',
}
type Lock = {
  type: 'LOCK',
}

type Action = EnterDigits | PressButton | Lock
```

Attempt: transition

```
function transition(
    stateMachine: StateMachine,
    action: Action
  ) : StateMachine {
  switch (action.type) {
    ...
  }
}
```

```
function transition(stateMachine: StateMachine, action: Action): StateMachine {
  switch (action.type) {
    case "ENTER_DIGITS":
      return {
        ...stateMachine,
        digits: action.payload
      };
    case "PRESS_BUTTON":
      if (stateMachine.digits === stateMachine.code) {
        return {
          state: "OPEN",
          code: stateMachine.code,
          digits: ""
        };
      }

      return {
        ...stateMachine,
        digits: ""
      };
```

Attempt: transition

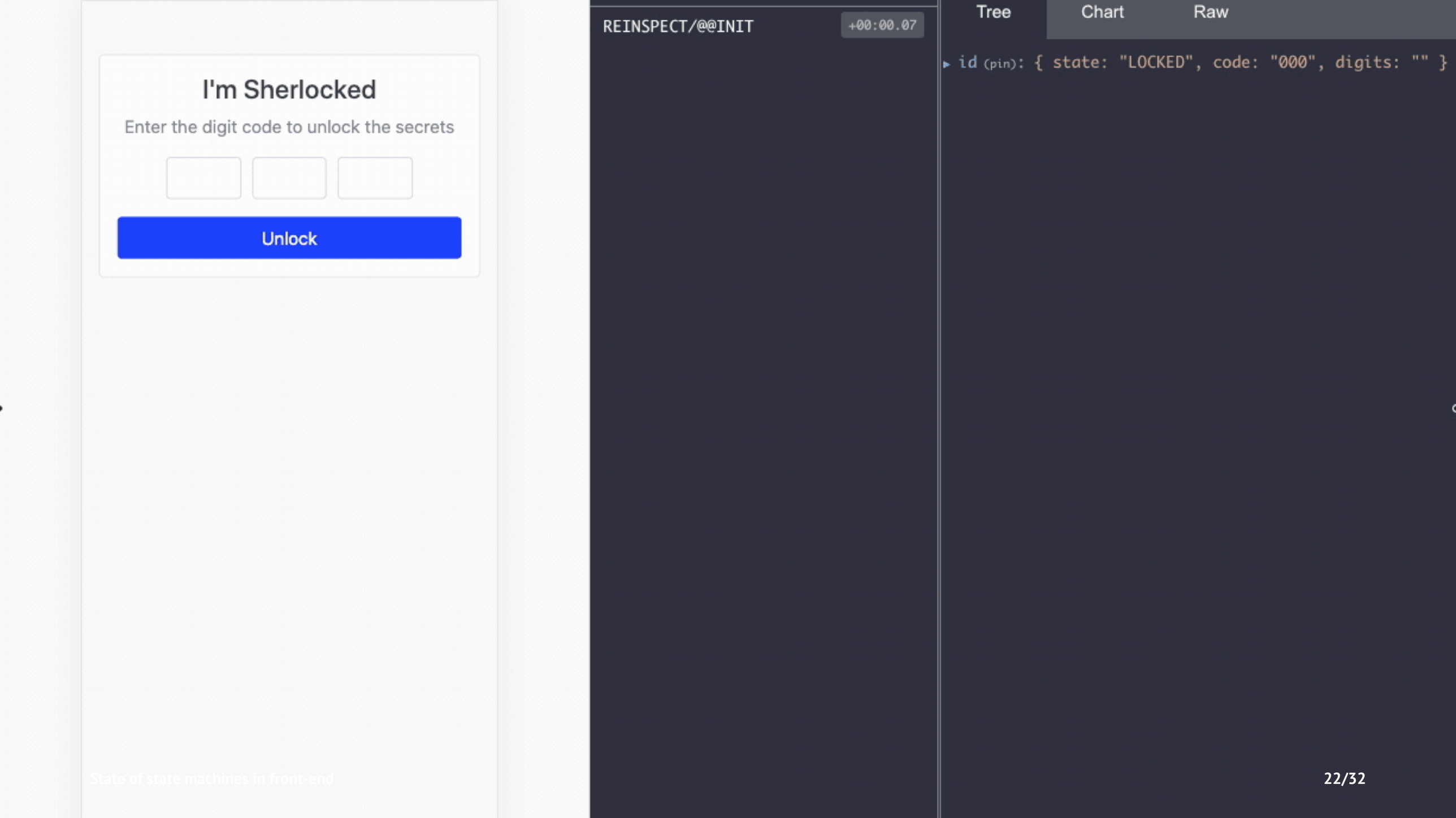
```
function transition(stateMachine: StateMachine, action: Action)
  : StateMachine {
  switch (action.type) {
    case "ENTER_DIGITS":
      if (stateMachine.state === "OPEN") return stateMachine;

      return {
        ...stateMachine,
        digits: action.payload
      };
    case "PRESS_BUTTON":
      if (stateMachine.state === "OPEN") return stateMachine;

      if (stateMachine.digits === stateMachine.code) {
        return {
          state: "OPEN",
          code: stateMachine.code
        };
      }

      return {
        ...stateMachine,
        digits: ""
      };
    case "LOCK":
      return {
        state: "LOCKED",
        code: stateMachine.code,
        digits: ""
      };
    default:
      return stateMachine;
  }
}
```

```
const [state, setState] = React.useState<StateMachine>(stateMachine);

const handleChange = (value: string) => {
  const action = { type: "ENTER_DIGITS", payload: value } as const;
  setState(transition(state, action));
};

const handleSubmit = (event: React.FormEvent) => {
  event.preventDefault();
  const action = { type: "PRESS_BUTTON" } as const;
  setState(transition(state, action));
};

const handleLock = () => {
  const action = { type: "LOCK" } as const;
  setState(transition(state, action));
};
```

Attempt: Redux [4]

```
function reducer(stateMachine: StateMachine, action: Action)
  : StateMachine {
}

const [state, dispatch] = React.useReducer(reducer, stateMachine);

const handleChange = (value: string) => {
  const action = { type: "ENTER_DIGITS", payload: value } as const;
  dispatch(action);
};

const handleSubmit = (event: React.FormEvent) => {
  event.preventDefault();
  const action = { type: "PRESS_BUTTON" } as const;
  dispatch(action);
};

const handleLock = () => {
  const action = { type: "LOCK" } as const;
  dispatch(action);
};
```

[4] https://codesandbox.io/s/lock-ts-gt2zn?file=/src/Lock4.tsx


I'm Sherlocked
Enter the digit code to unlock the secrets
Unlock
REINSPECT/@@INIT
+00:00.07
Tree
Chart
Raw
id (pin): { state: "LOCKED", code: "000", digits: "" }

Attempt: xstate [5]

```
const stateMachine = Machine(
  {
    id: "lock",
    initial: "locked",
    states: {
      locked: {
        on: {
          ENTER_DIGITS: 'locked',
          PRESS_BUTTON: 'open'
        }
      },
      open: {
        on: {
          LOCK: "locked"
        }
      }
    }
  }
);
```

[5] https://codesandbox.io/s/lock-ts-gt2zn?file=/src/Lock5.tsx

```
const stateMachine = Machine(
  {
    id: "lock",
    initial: "locked",
    context: {
      code: CODE,
      digits: ""
    },
    states: {
      locked: {
        on: {
          ENTER_DIGITS: {
            target: "locked",
            actions: assign({
              digits: (_context, event) => {
                return event.payload;
              }
            })
          },
          PRESS_BUTTON: 'open'
        }
      },
      open: {
        on: {
          LOCK: "locked"
        }
      }
    }
  }
);
```

```
const stateMachine = Machine(
  {
    ...
    states: {
      locked: {
        on: {
          ...
          PRESS_BUTTON: [
            {
              target: "open",
              cond: "isCodeCorrect"
            }
          ]
        }
      },
      ...
    }
  },
  {
    guards: {
      isCodeCorrect: (context) => {
        return context.code === context.digits;
      }
    }
  }
);
```

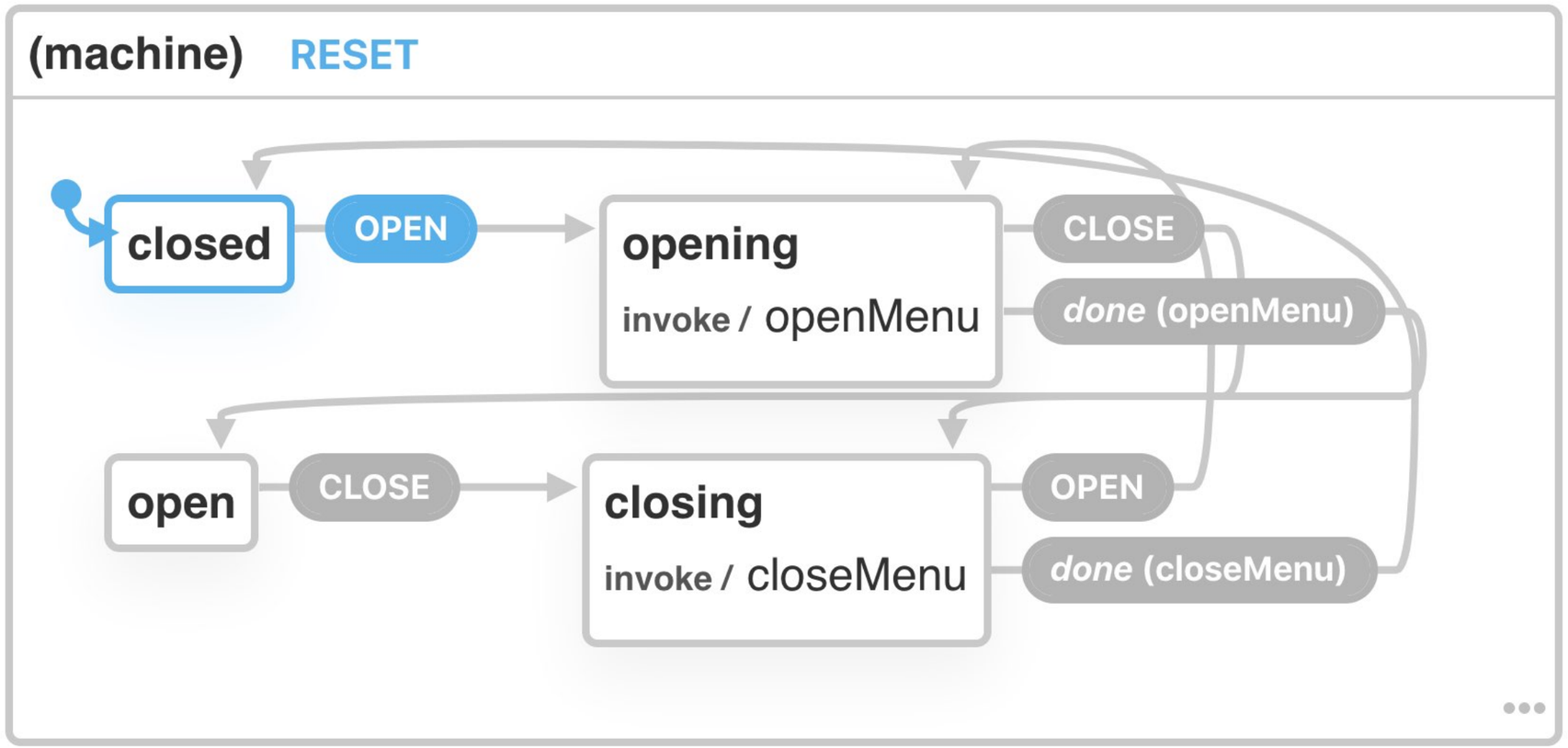
xstate

- Framework agnostic
- Powerful real-world abstractions
  - Nested/history states
  - Parallel states, Delayed Events, Transient transitions etc.
- Statechart Visualizer

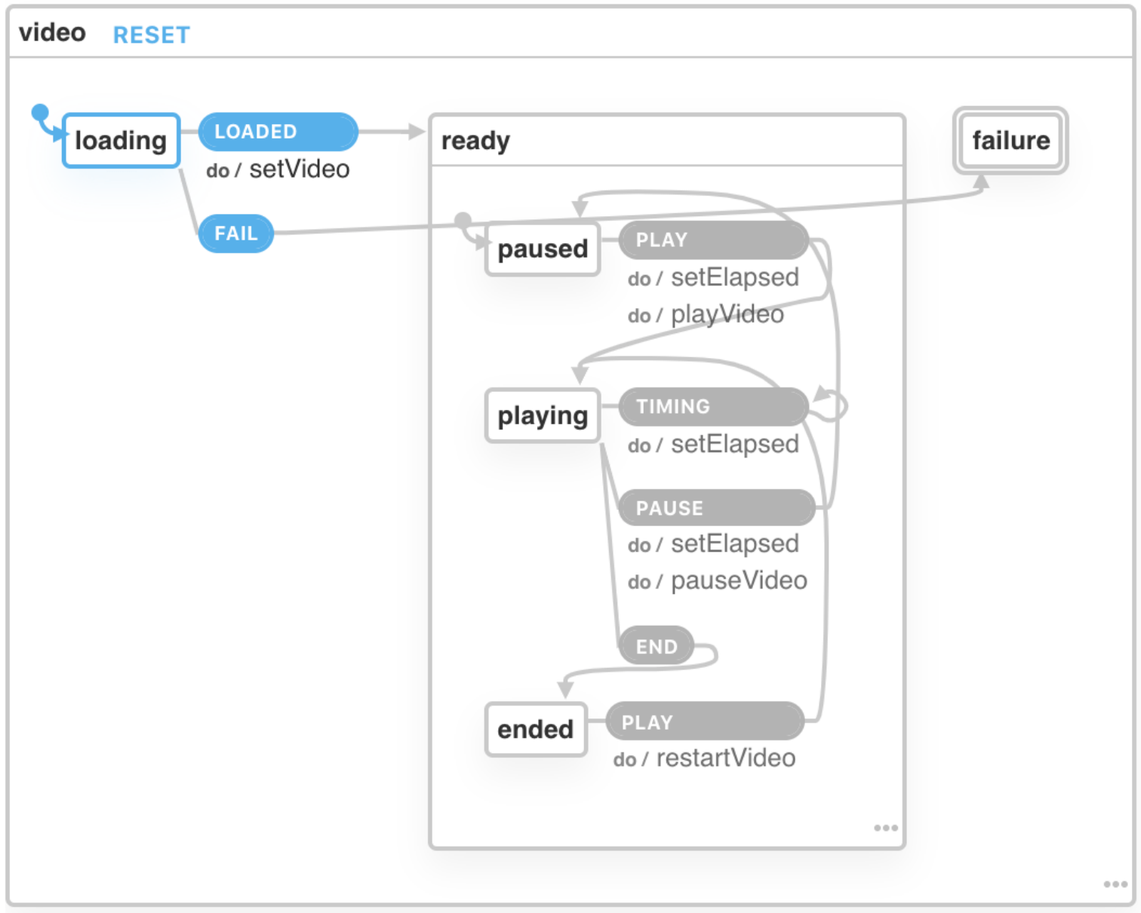

locked
ENTER_DIGITS
do / assign digits
PRESS_BUTTON
[isCodeCorrect]
open
LOCK

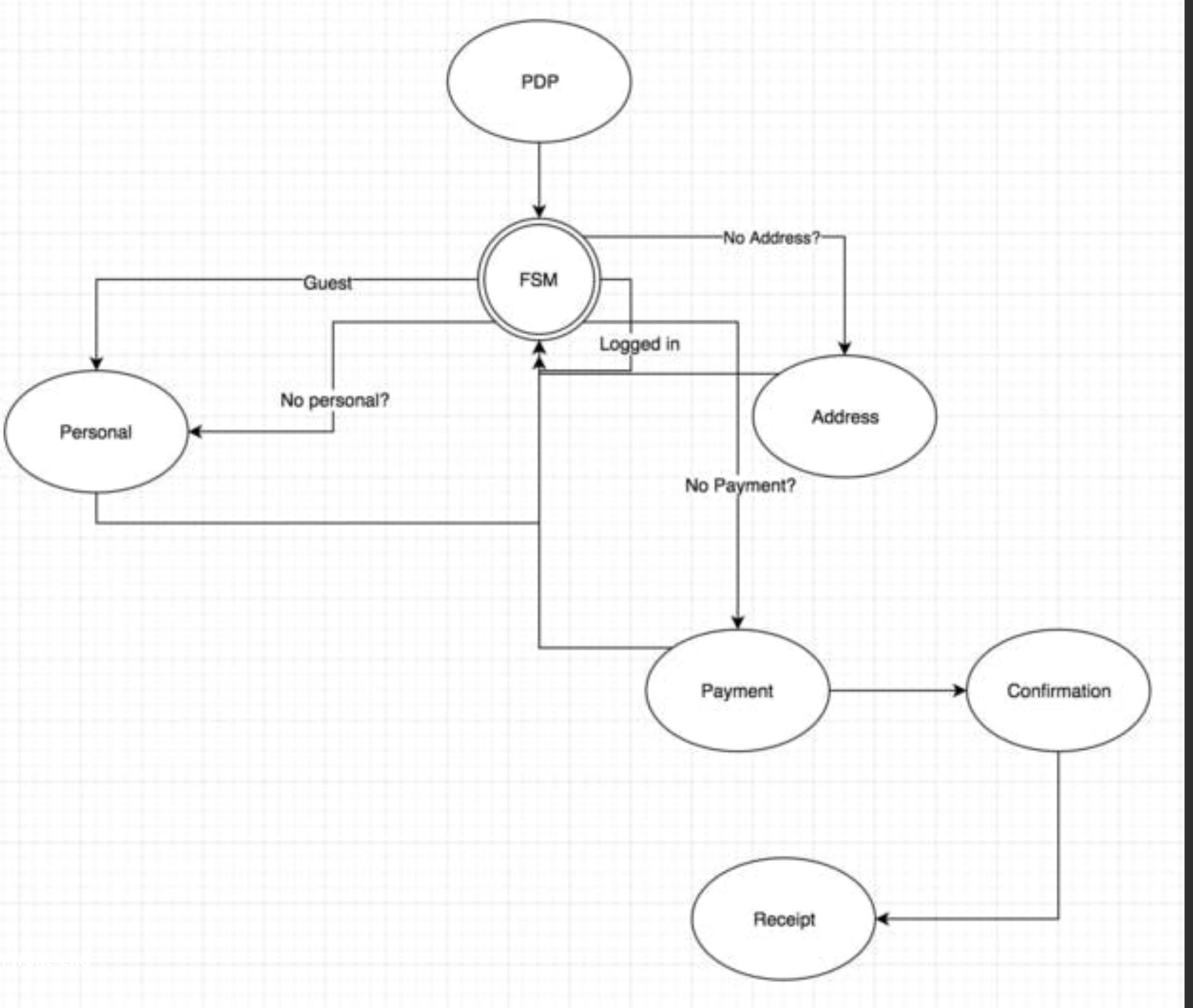
Some use cases

Navigation menu



Video player




PDP
FSM
No Address?
Guest
Logged in
No personal?
Personal
Address
No Payment?
Payment
Confirmation
Receipt

Thanks