

# An Expressive DSL for Parametric Monitoring

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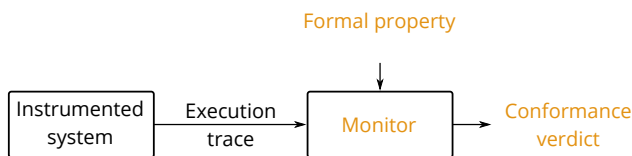
## The MODMED Project

- Industry of Medical Systems
- Bring formal monitoring
- Partnership with local companies
- Case study on a computer assisted surgery system



## System monitoring to

- Check the correctness and the robustness of the system
- Validate the assumptions made on the environment
- Better understand the usage of the system
- Produce evidences for certification



## A DSL to facilitate property formalization

### Language objectives

- **Intuitive** and yet formal
- Expressive enough to fit **practical needs**
- Allow easy exploitation of **data** carried by events

### Methodology to design the DSL

1. Gather properties that the system should verify
2. Extract a representative subset of those properties
3. Design a language allowing to express this subset concisely
4. Gather feedbacks from partners
5. Validate the language with field practitioners

### Language features

- Strong focus on **temporal properties**
- Based on known **specification patterns**
- Most of the constructions can be **composed**
- **Declarative** style
- **Constraints on parameters** of events



## Case study: ExactechGPS Total Knee Arthroplasty

### Surgery workflow



System initialization



Sensors calibration



Anatomic points acquisition



Cut planning

### Abstract view of an execution trace

```
EnterState {
  state: "LocalizerConnection" }
CameraConnected {}
ExitState {
  state: "LocalizerConnection" }
EnterState {
  state: "TrackersConnection" }
SearchTrackers {
  types: ["P", "F", "T", "G"] }
TrackerDetected { ty: "P" }
TrackerDetected { ty: "F" }
TrackerDetected { ty: "G" }
TrackerDetected { ty: "T" }
ExitState {
  state: "TrackersConnection" }
...
Temperature { value: 49.75 }
ActionNext {}
EnterState {
  state: "AcquiAnkleMalleolus" }
AcquisitionBegin {}
AcquisitionCancel {}
ActionNext {}
AcquisitionBegin {}
AcquisitionSuccess {}
...
EnterState {
  state: "AcquiTibiaCenter" }
...
Temperature { value: 54.50 }
ExitState {
  state: "CutPlanning" }
EnterState {
  state: "CutNavigation" }
...
EnterState {
  state: "KneeControl" }
```

### Natural and formalized properties

*"The temperature is never lower than 45 degrees after the camera is connected."*

```
after first CameraConnected,
absence_of Temperature t
  where t.value < 45.0
```

*"All the searched trackers are detected before leaving the state TrackersConnection"*

```
between SearchTrackers st
and ExitState e
  where e.state=="TrackersConnection",
forall ty in st.types,
occurrence_of TrackerDetected td
  where td.ty == ty
```

*"Cancelling an acquisition prevents it from succeeding"*

```
since AcquisitionCancel
until AcquisitionBegin,
absence_of AcquisitionSuccess
```

*"The system does not allow navigating a cut before terminating its planification"*

```
ExitState exit
  where exit.state == "CutPlanning"
precedes EnterState enter
  where enter.state == "CutNavigation"
```