Systems of Action

A stack model for capability classification
Systems of Action

A class of systems that

• Can sense or observe a phenomena, process or machine

• Process observations and search for anomalies, undesired state changes and other deviations that must be dealt with.

• Plan and execute / (recommend execution of) actions to bring the observed phenomena, process or machine back to its desired operational state.

• Monitor effects of actions and re-plan if action did not have intended effect on process state

making better decisions under stress and uncertainty

The term was coined by Statoil in an attempt to illustrate the transition from record keeping to action optimisation.
Motivation
Failed Safety
Critical Decisions

- Situational awareness
- Trustworthiness
- Culture
- Decision quality
A manually controlled process

Manual Control
- Interpret state
- Perform tasks

Drilling Control System
- Top Drive
- Mud Pumps
- Hoisting Drive
- Topside Sensors

Real Bore Hole State
I have to make frequent decisions and many of them depend upon readings from sensors that can be correct, noisy, random, unavailable, or in some other state.

The decisions I have to make often have safety consequences, they certainly have economic consequences, and some are irreversible.

At any point in time there may be three or four actions I could take based on my sense of what’s happening on the rig.

I would like better support to determine how trustworthy my readings are, what the possible situations are and the consequences of each action.
Human brain - planets most sophisticated and vulnerable system of action

- Emotions trumps facts (irrationality)
- Limited processing capacity
- Need to rest, easily bored
- Inconsistency across exemplars
- Creative, easily distracted
- Values (ethics and morale)
- Mental illness (irrationality)

How to avoid clusterfucks?
add active computer support

Intelligent Drilling Assistant

Real-time data

Manual Control

Recommend actions in context of process state

Drilling Control System

Top Drive

Mud Pups

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Real Bore Hole State
the drilling assistant

Intelligent Drilling Assistant

Drilling Advisor
- Uncertainty model
- Causality model
- Reasoning
- Plans

Drilling Simulator
- Hydraulic model
- Mechanical model
- Temperature model

State & Events

Real-Time Data

Drilling Control System

Actions

Action to be executed by human, but concept opens up for more computer control in the future.

i.e. Drilling advisor can be turned into “synthetic driller”.
the problem

How to architect systems of action?

- How to make the architecture communicable?
- How to structure requirements?
- How to structure solutions?
- What capabilities do we need?
- What dependencies do we have?
- Where are the interfaces?
- What components to use?
<table>
<thead>
<tr>
<th>Capability Stack</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Action Optimization</td>
<td>What is the best action to take for the business?</td>
</tr>
<tr>
<td>Local Action Optimization</td>
<td>What is the best action to take for control or safety?</td>
</tr>
<tr>
<td>Situational Awareness</td>
<td>What is the process state and where is it heading?</td>
</tr>
<tr>
<td>Uncertainty and Validation</td>
<td>What do we know for certain and what are we estimating?</td>
</tr>
<tr>
<td>Physical System Behavior</td>
<td>What can we infer about performance and changes in the physical system?</td>
</tr>
<tr>
<td>Physical System Sensing</td>
<td>What are we measuring directly, with what accuracy?</td>
</tr>
</tbody>
</table>

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technological perspective

- **Global Action Optimization**: Well-lifecycle planning and scheduling, resource management tools.
- **Local Action Optimization**: Task-level planning and scheduling; decision utility models; ideal action under uncertainty; procedure synthesis.
- **Situational Awareness**: State estimation and transition tracking; hazardous state identification; human operator models; state-space representations.
- **Uncertainty and Validation**: Probabilistic and statistical models; confidence measures.
- **Physical System Behavior**: Fluid dynamics models; geophysical models; Equipment models.
- **Physical System Sensing**: Direct sensors and detectors; data stream acquisition and processing; calibration; distribution.

Increasingly Actionable Information
user perspective

Global Action Optimization
- Global actions considered in context of best-available technical support and trustworthiness

Local Action Optimization
- Less expertise required to convert processed information into ideal actions; irrelevant information hidden from action context; good technical support for action trustworthiness

Situational Awareness
- System behavioral complexity reduced through decoupling and known planned interactions; reduced state confusion; some expertise required to map onto possible actions

Uncertainty and Validation
- The degree of confidence in observations and inferences is well established; justifiable trustworthiness for action input

Physical System Behavior
- Substantial expertise required to infer actions given changes in physical system behavior and interpretation of causal mechanisms

Physical System Sensing
- Considerable expertise required to convert raw observations into actions; little technical support for action trustworthiness
Business procedural agents for goal-directed operations resource management, conflict resolution, logistics, ordering, etc. Technology: intelligent agents.

Procedural reasoning about operations; establishing operating goal, selecting procedures, executing procedures including workarounds. Computing and ranking idea operator actions under uncertainty. Technology: intelligent agents; action utility models.

Procedural reasoning about operator’s mindset. Adjusting presented content to maximize relevant information. Technology: intelligent agents; intelligent cognitive agents; expected value of revealed information.


Causal probabilistic network models (Bayesian reasoning) process observations and prior probabilities into (a) latent variables or (b) computed probability densities. Technology: causal probabilistic networks.

N/A
product integration perspective

Global Action Optimization
- Intelligent agents: AOS JACK
- Intelligent analytics: Enrich Analytics Platform

Local Action Optimization
- Intelligent agents: AOS JACK, AOS C-BDI
- Utility models: Statoil internal
- Middleware: Any event-driven
- Cognitive agents: AOS CoJACK

Situational Awareness
- Expected value revealed information: BN + Utility model + Action model
- Middleware: Any event-driven
- Causal probabilistic networks: Hugin Expert, Norsys Netica, UCLA SamIam, Mathworks Matlab Bayes Net Toolbox, Bayes Server, R graphical models
- Utility models: Statoil internal
- System state models: Safeware Engineering SpecTRM, UML SysML, NASA JPL MDS, Mathworks Simulink Stateflow
- Middleware: Any event-driven

Uncertainty and Validation
- Physical System Behavior

Notes: A) Utility models are simply tables of cost values assigned to actions or outcomes, so we do not identify specific commercial tools for these. These tables can be done with Excel or with the companion BN tools. B) EVRI is a way to use BN + utility model programming to control displayed content; there are no known commercial products. C) MDS product requires license from Caltech. D) SamIam product requires license from UCLA for commercial use. Dr. Matt Barry.
Building Blocks perspective

- Global Action Optimization
- Local Action Optimization
- Situational Awareness
- Uncertainty and Validation
- Physical System Behavior
- Physical System Sensing

Automated planning and scheduling

Machine learning (Bayesian) + Physics (Cyb)

Decision / game theory

Rational agent

- has goals
- models uncertainty
- chooses action with optimal expected outcome for itself
- Examples:
  - human (on a good day)
  - intelligent software agent
Summary

**Systems of Action**

Analyse data in context of process and recommends the best possible action

Combines cybernetics, AI and visualisation technologies

How to architect?

**Capability stack**

 Helps architecting systems of action

Simplifies stakeholder communication