Design for the Unexpected: How to Eliminate Traffic Jams

Paul Valckenaers

2013-June-13

An Operating System for the Real World

- OS (kernel) is
  - A resource manager
  - For resources in the computer domain
- Low tolerance for *compute overhead*

but fortunately

- Easy (de)allocation and cheap resources

- Real-world resources:
  - Represent more value
  - Their allocation has serious impact on us
- Non-trivial (de)allocation

but fortunately

- Significant *compute efforts* are justifiable

An Operating System for the Real World

- How can we design such INFRASTRUCTURE?
- Beyond ICT
- *Application-domain-Knowledgeable*

- **2 shocking events** in my life: *Cyber-apartheid*
  - MDA
    - **Model?**-driven Architecture
    - *Use Erlang/OTP and….*
  - IoT
    - Internet of **Things?**
    - *Internet talking to things*

An Operating System for the Real World

- ICT People are blind
  - Cf. previous slides
  - E.g. paper review:

    No contribution since *already solved* while only “programmable” in a tool/environment

    Not joking!
- Application domain experts
- **Why do they fail?**
  - Focus on performance in the application domain
  - Focus on decision making in the application domain

Infrastructure Design = *Design for the Unexpected*

- The wrong approach:
  - **Focus on the decision making** - aimed at objectives (i.e. performance indicators)
- Why?
  - Arbitrary constraints are unavoidably introduced
- Infrastructure design needs to avoid the abitrary because
  - Only “1-5%” of the full potential is recognised when designing an ICT infrastructure
- Yet, it needs to be knowledgeable in the application domain

Design for the Unexpected

- Novel ICT application domains where the application domain experts believe they know best, **know less than 5% of the full potential** before large scale deployment has become a reality

- These experts are only a small fraction of professionals active in the domain
- Some key technology and contribution may still need to come from other domains
  (analogy: Kursk rescue by *Norwegian* deep-sea divers)

Design for the Unexpected

- Novel ICT application domains where the application domain experts believe they know best, know **less then 5% of the full potential** before large scale deployment has become a reality

- Working conditions after going full scale are unknown (analogy: fire fighting after first Gulf war)
- These experts don't know best!
- **These experts will be beaten by their future selves!**

Design for the Unexpected

- Novel ICT application domains where the application domain experts believe they know best, know **less then 5% of the full potential** before large scale deployment has become a reality

- **Smart traffic**
- **Smart factories**
- **Smart grid**
- **Smart health care**
- **…**
- Probably still are below this “5%” today (= unconfirmed but plausible)

Design for the Unexpected

- Only identify what is (not) relevant
- Don’t rely on expectations
- Rely on what is certain
- Or at least be prepared to undo…

- Roads, cars, parking space…
- Trips, commuting, …
- Decision making ??
- **To BE, that’s…**

Design for the Unexpected

- Only identify what is (not) relevant
- Don’t rely on expectations
- Rely on what is certain
- Or at least be **prepared to undo**

- Resource allocation
  - Explicit
  - Mandatory
- *For the unexpected*
  - *Minimized*
    - Including state and trajectory requirements

Design for the Unexpected

- Only identify what is (not) relevant
- Don’t rely on expectations
- Rely on what is certain
- **Critical user mass**

- Resource types
- Resource instances
- Activity types
- Activity instances
- VIP-Architecture
  - E-Butlers and
  - E-Professionals
- Aggregates/composite
  - Time-varying

Intelligent Traffic - MODUM

- Resource types
- Resource instances

- Activity types
- Activity instances

- VIP-Architecture
  - E-Professionals
  - E-Butlers
  - Erlang is instrumental…

- Road segments
- Crossings
- Car, bus, train, tram (vehicle/seat)
- Bicycle
- People
- …

- Commute routing
- Multi-modal trip
- …

Intelligent Traffic - MODUM

- Resource types
- Resource instances

- Activity types
- Activity instances

- VIP-Architecture
  - E-Butlers and
  - E-Professionals

- Real-world counterpart

- State (track)
- History (trace)

- Agenda (resources)
- Intention (activities)

Intelligent Traffic - MODUM

- Real-world counterpart

- State (track)
- History (trace)

- Agenda (resources)
- Intention (activities)

- Mirror reality
- Coherent and consistent
- Not necessarily in a desired state

- Maintain mirror image *whatever happens* and cope with the unexpected
- Note: SSOT

Intelligent Traffic - MODUM

- Better forecasts of traffic jams, …
  - Use state-of-the-art traffic models for "dynamic network loading"
  - Good at "back-propagation"
  - Use "intentions of activity instances" for forward propagation
- Current state-of-the-art forecasting
  - Recent state info
  - Historical data
  - Models
  - …
  - Predict state for the next hour?
  - OK for "*businessclass*"
  - …

Intelligent Traffic - MODUM

- Better forecasts of traffic jams, …
  - Use state-of-the-art traffic models for "dynamic network loading"
  - Good at "back-propagation"
  - Use "intentions of activity instances" for forward propagation
- Intentions ?
  - Results of decision making within activity and resource instances!
  - Design for the unexpected? How?

Intelligent Traffic - MODUM

- Intentions ?
  - Results of decision making within activity and resource instances!
  - Design for the unexpected? **How?**
  - In the real world decision making mechanisms exist
  - ALWAYS
- Mirror reality
  - Mirror decision making in *executable* models
    - Efficient code
    - Human, nature, …
    - Compute-heavy code
  - Virtual execution, much faster than reality, generates candidate solutions and selects the intentions (N.B. SSOT)

Intelligent Traffic - MODUM

- Intentions ?
  - Results of decision making within activity and resource instances!
  - Design for the unexpected? **How?**
  - In the real world decision making mechanisms exist
  - ALWAYS
- Mirror reality
  - Mirror decision making in executable models
    - Efficient code
    - Human
    - Compute-heavy code
  - Virtual execution of intentions generates short-term forecasts of routing, congestion levels…

Intelligent Traffic - MODUM

- Better forecasting
  - Embed-able in current ITTS, unmanaged, ...
  - Only incremental improvement
  - Superior when an adequate percentage of users contribute to, observe and use forecasts
  - Modeling challenges
    - *Butterfly effects*

- Eliminate and/or drastically reduce traffic jams
  - Requires managed infrastructure
    E.g. bus lanes used at full capacity
  - Requires all users to follow instructions !!!
  - Eliminates modeling challenges

Intelligent Traffic - MODUM

- Better forecasting
  - Embed-able in current ITTS, unmanaged, ...
  - Only incremental improvement
  - Superior when an adequate percentage of users contribute to, observe and use forecasts
  - Modeling challenges
    - *Butterfly effects*

- Eliminate and/or drastically reduce traffic jams
  - Requires managed infrastructure
    E.g. bus lanes used at full capacity
  - Requires all users to follow instructions !!!
  - Eliminates modeling challenges

Intelligent Traffic - MODUM

- Eliminate and/or drastically reduce traffic jams
  - Requires managed infrastructure
    E.g. bus lanes used at full capacity
  - Requires all users to follow instructions !!!
  - Eliminates modeling challenges

- Most of the time
  - User follow their own instructions
  - "You are your own boss"
- Except when
  - "Users fail to *work things out*"
- In which case
  - community policies will arbitrate

Intelligent Traffic - MODUM

- Traffic jams
  - Only remain an issue where capacity is insufficient
  - Policy must handle this
    - Priority on behalf of past behaviour
    - Anti-starvation
    - Pricing
    - …

- Traffic jams
  - Don't touch/bother *uninvolved* users
  - Optimize location and time
    - Home, office, …
- Abolishment of
  - "If I had known this …"
  - "No good deed goes unpunished"

Intelligent Traffic - MODUM

- Obstacles to abolishment of traffic jams
  - Comfort zones are a major issue
  - Key decision makers may have *selfish* preferences
- The traffic specialist community
  - Designs for the expected
  - insists on a system that has the "*right*" objectives
  - Ignores that the infrastructure can be and should be agnostic concerning objectives

Intelligent Traffic - MODUM

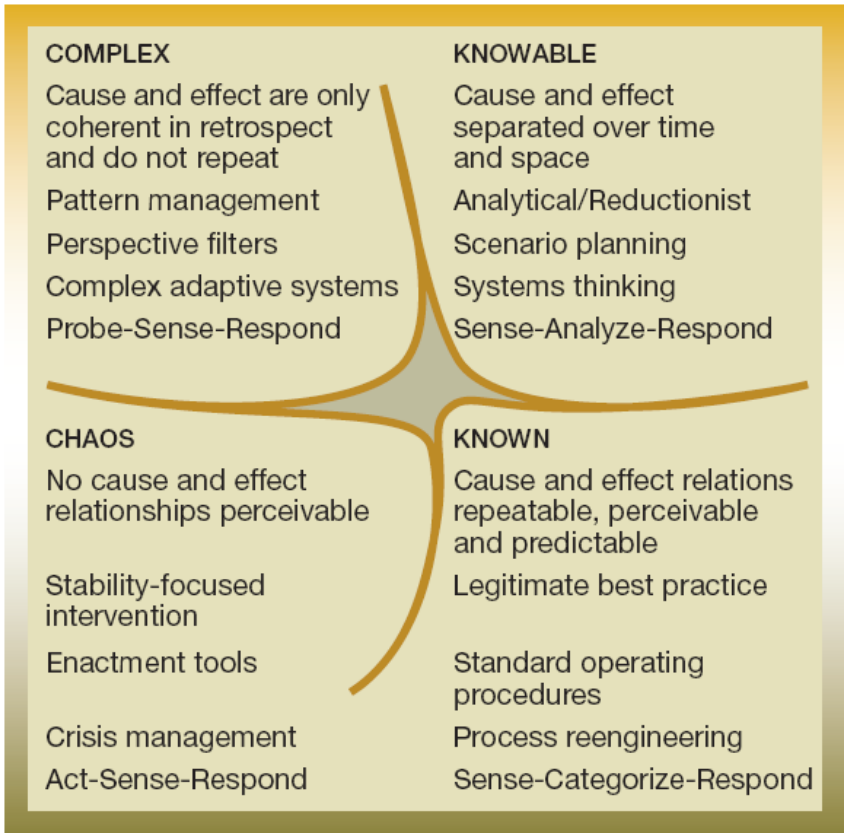
- Obstacles to abolishment of traffic jams
  - Know how to address this exists !
- Privacy
  - Ignorance of hard privacy-enhancing technology
  - Unwilling to develop a privacy-enhancing architecture
  - Unwilling to develop the appropriate middle-of-the-road system.

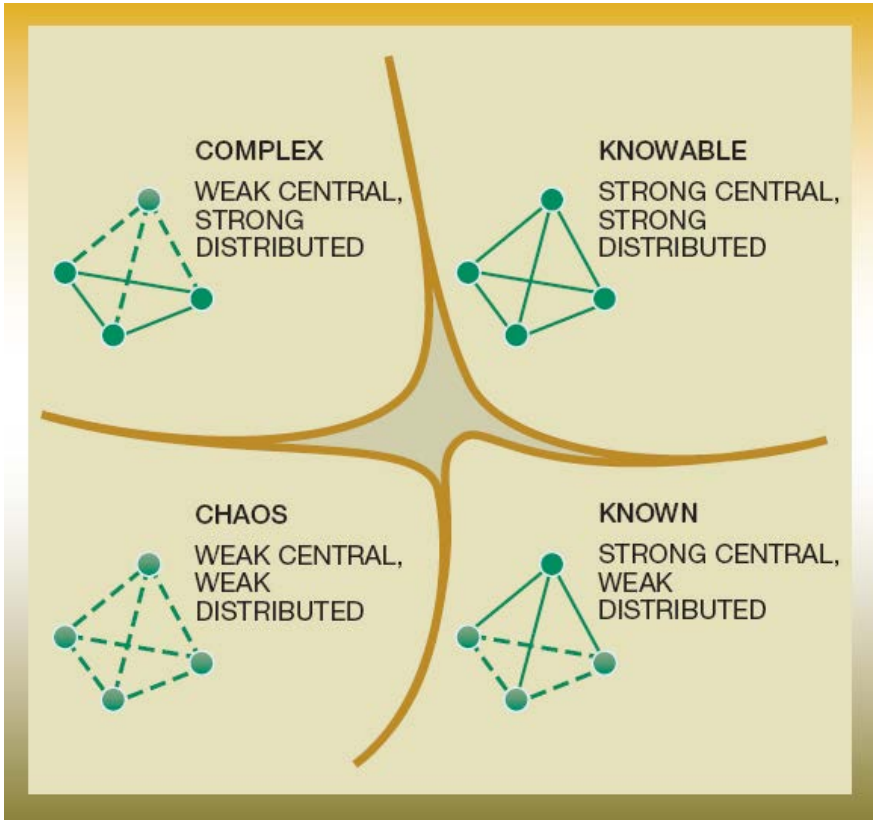
Conclusion

- A group of West Point graduates were asked to manage the playtime of a kindergarten as a final year assignment.
- The cruel thing is that they were given time to prepare. They planned; they rationally identified objectives; they determined backup and response plans. They then tried to “order” children’s play based on rational design principles, and, in consequence, achieved chaos.
- They then observed what teachers do.
- Experienced teachers allow a degree of freedom at the start of the session, then intervene to stabilize desirable patterns and destabilize undesirable ones; and, when they are very clever, they seed the space so that the patterns they want are more likely to emerge.

- OUT-OF-CONTROL performs better ?

- Waldrop, M., “Complexity, the Emerging Science at the Edge of Order and Chaos”, VIKING, London, 1992.





- R. Lewin, Complexity: Life at the Edge of Chaos, University of Chicago Press, Chicago, IL (1999).