

Some thoughts on conceptual modelling

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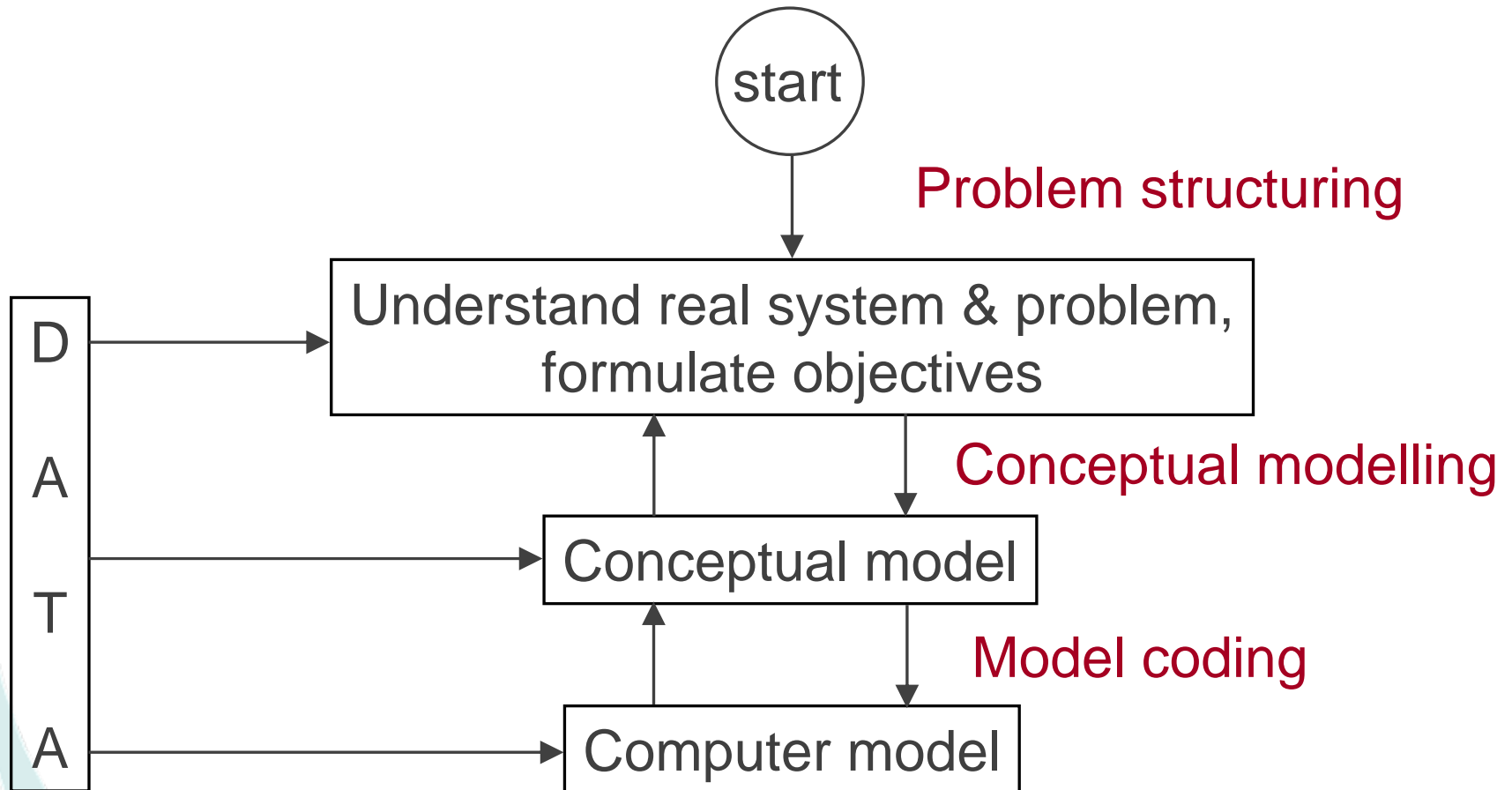
Contents

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- Objectives of conceptual modelling
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- Some principles of conceptual modelling
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What is conceptual modelling?

- Definition of conceptual model:
 - “a software independent description of the model that is to be constructed” (Brooks and Robinson, 2001)
- Conceptual modelling is the process of deciding what to include in the model
 - Entities, interactions, rules of behaviour
 - Real system + boundary + assumptions + simplifications
 - Model formulation

Modelling process



Advice from literature

“The process by which a .. management scientist derives a model .. can best be described as an intuitive art” (Shannon, 1975)

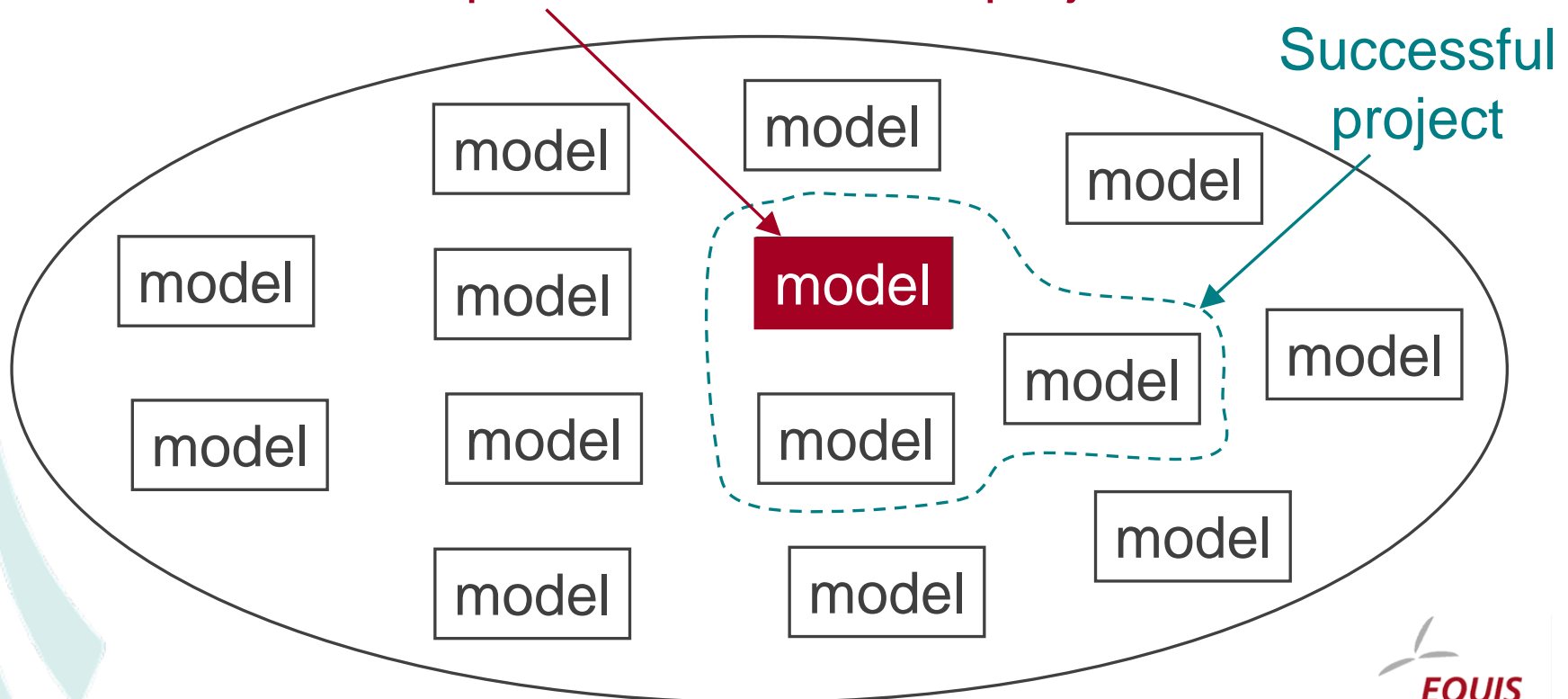
“I now strongly feel that the most difficult aspect of a study is that of determining the appropriate level of model detail” (Law, 1991)

Advice from literature

- Good knowledge of real system
- Relate to objectives
- Outputs
- Inputs (experimental frame)
- Past experience
- Advantages of a simple model

Objectives of conceptual modelling

- Choose the best model
 - best overall performance for the project



Model performance

Results

1 Scope of model output. 2 Accuracy. 3 Understanding.

Future use

4 Model portability.

Confidence in the model

5 Verification. 6 Validation. 7 Credibility.

Resources

8 Build time. 9 Run time. 10 Time to analyse results.

11 Hardware requirements.

Nature of conceptual modelling – an O.R. problem

Objective function:

Maximise model performance

Subject to:

conceptual modelling time + time for other tasks

\leq total time available

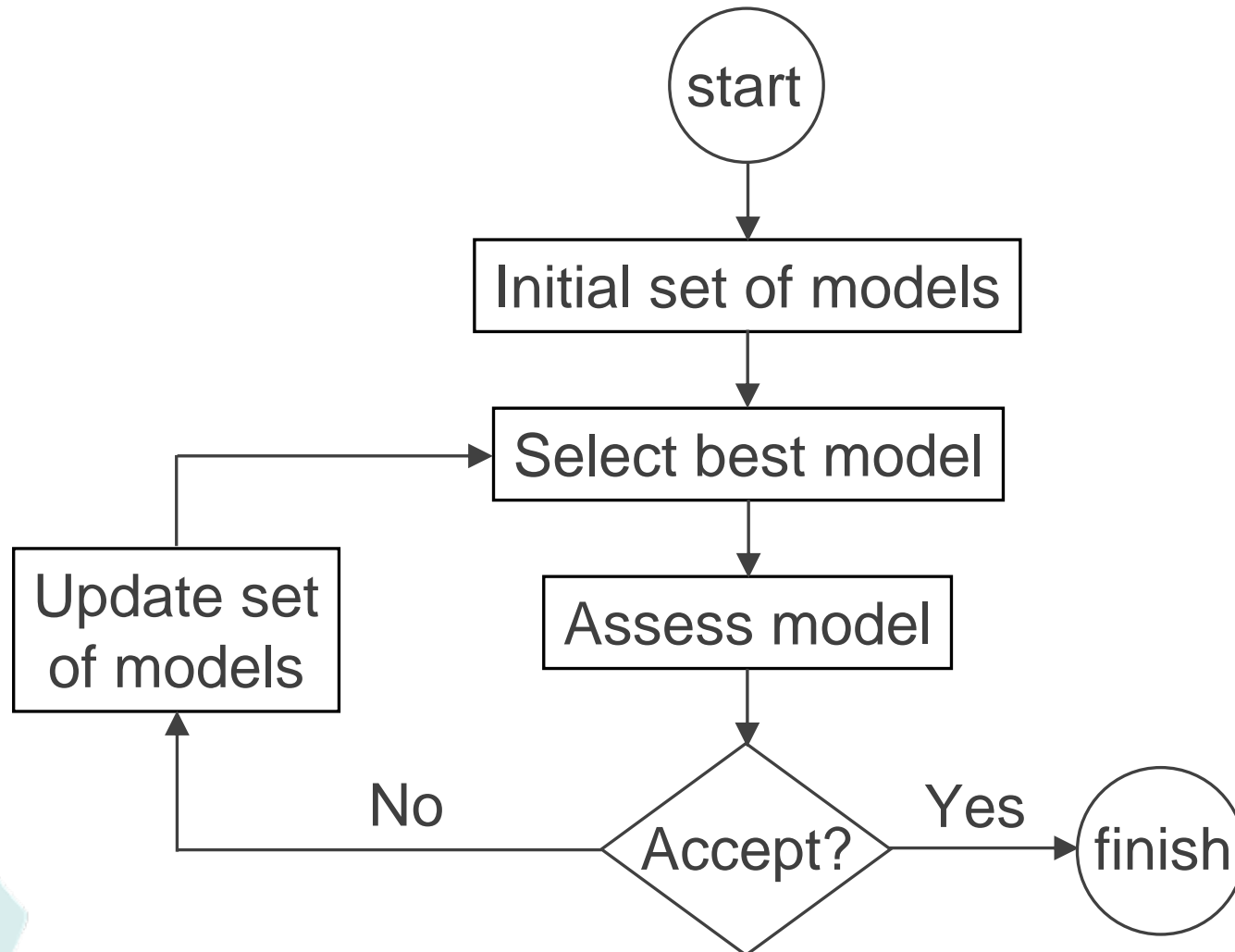
Controllable decision variables: Model

Uncontrollable variables: Other tasks

Solution approach

- Specify objective function more precisely
 - relative importance of model performance aspects
- Identify alternative models
- Time required for conceptual modelling
- Predict model performance
 - relationship between model characteristics and performance

Conceptual model selection process



Improving understanding of conceptual modelling

- How experts model
- Predicting model performance
- Model comparison studies

Evidence of how experts model

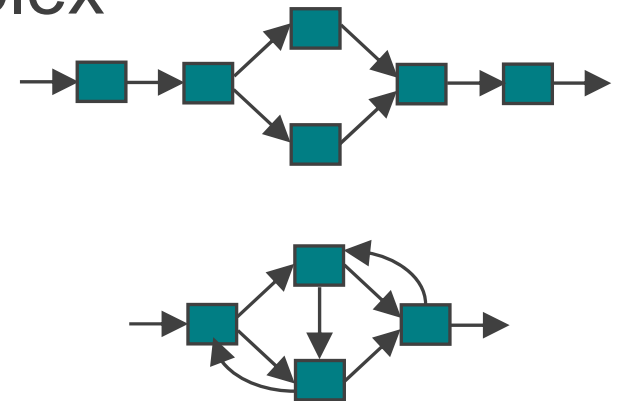
- Willemain (1994, 1995)
- Survey of 12 experts
 - self description
 - opinions on effective model, modeller, process, client
- Experiment
 - 1 hour think-aloud solving O.R. problem
 - Analysed transcripts: context, structure, realisation, assessment, implementation

Evidence of how experts model

- Creative process
 - analogies, drawing and doodling
 - many mentions for effective modeller
- Iterative process of model development and assessment
 - imagine how model will perform
 - consider options and narrow down

Predicting model performance

- Relate performance to model characteristics
- Level of detail, simple / complex
 - often mentioned
 - no definition
 - no agreed measurement
 - too general
- Suggest: size, connectedness, calculations
 - still several ways of measuring these



Student experiment (1995)

- 33 MSc students, 4 manufacturing models
- Questions on understanding
 - related to size and complexity
- Measure build time
 - related to calculational complexity

Model comparisons and simplification

- Manufacturing (2 cases)
- Population genetics
- Wheat

Manufacturing

Models of:	Production and assembly lines
Objective:	Improve throughput
Outputs:	Throughput (queues etc.)
Inputs:	Cycle times, breakdowns, set-ups, production schedule

Manufacturing

Alternatives:

- Discrete-event simulation model
- Simplified model
- Analytical model

Simplified by:

Bottleneck analysis

Benefits:

- Increased understanding
- Identification of errors
- Easy experimentation

Population genetics

Models of:	Poppy genes
Objective:	Improve understanding
Outputs:	Variance of allele frequency
Inputs:	Population characteristics

Population genetics

Alternatives:

- Individual plant-based model
- Analytical model

Simplified by:

- Analysis of model mechanisms
- Model output
- Statistical analysis

Benefits:

- Increased understanding
- Theoretical results
- Easy experimentation

Wheat

(E.C. Environment programme)

Models of:	Wheat growth
Objective:	Predict yield under climate change
Outputs:	Yield
Inputs:	Soil and plant characteristics, daily weather data

Wheat

Alternatives:

- Detailed daily model
- Aggregated model

Simplified by:

- Analysis of model mechanisms
- Sensitivity analysis

Benefits:

- Increased understanding
- Theoretical results
- Easy experimentation

Model comparisons

- Benefits of simplification
 - understanding, experimentation, additional results, cross validation and verification
- Drawbacks of simplification
 - time-consuming, reduced experimental frame, reduced validity
- Feasibility
 - output is an average
- Methods
 - sensitivity analysis, analysis of mechanisms, bottleneck

Principles of conceptual modelling

- Creative process
- Aiming for best project performance
 - or, at least, a successful project
- Objectives, inputs, outputs, data
- Relate characteristics and performance
- Start with medium detail (and add)
- Consider building more than one model
- Two levels of simplification
 - based on knowledge of system
 - based on analysis of the model
- Document
 - e.g. list of assumptions and simplifications

Further research

- Study experts
 - Willemain experiment
 - Real projects
- Model characteristics and performance
 - Alternative measures
 - Experiments to compare performance
- Model comparisons
- Simplification
 - techniques, when and how to apply
 - meta-modelling
- Documentation
- How to teach conceptual modelling

Conclusions

- Conceptual modelling is very important
- Issues are not well understood
- Lack of advice
- Lack of research
- Research is difficult
 - many dimensions: modeller, client, application, objectives
 - case study / experimentation