

## The Systems Integration Technical Risk Assessment Model based on Bayesian Beliefs Networks

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### Problem Definition

- What modelling method and intelligent decision support tool can be applied to evaluate System Integration Technical Risks?
- How expert knowledge can be captured, maintained and applied to assist System Integration Technical Risks assessment?

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## Research Goals

- Identify an approach to solve the problem
- Formulate SI technical risks modelling principles
- Implement modelling tool prototype with some constraints
- Scope future research directions and tool upgrades

## Presentation overview

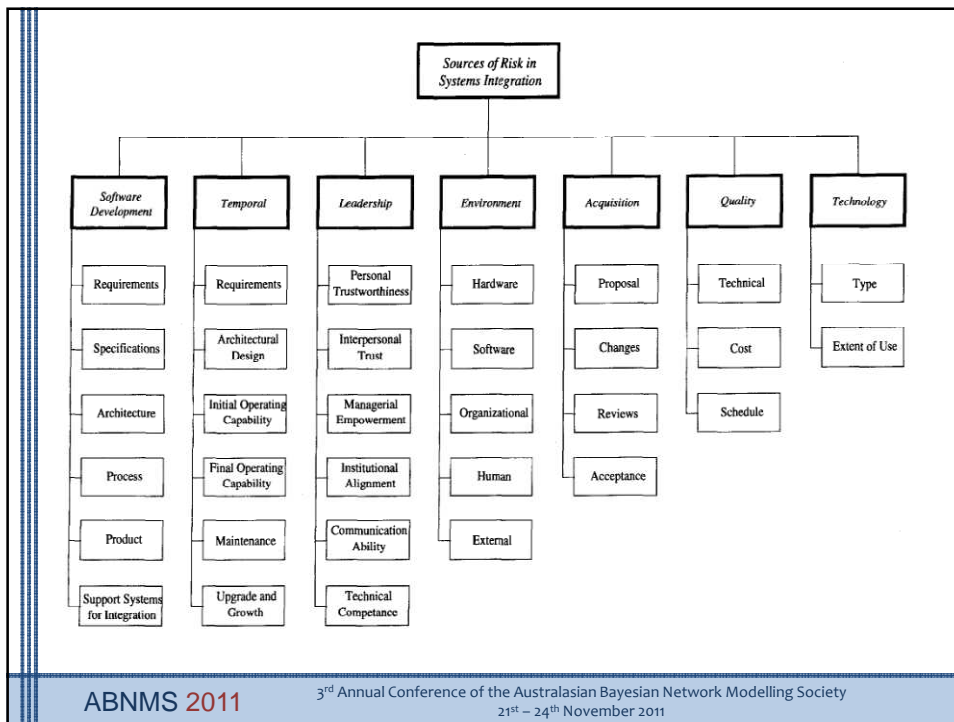
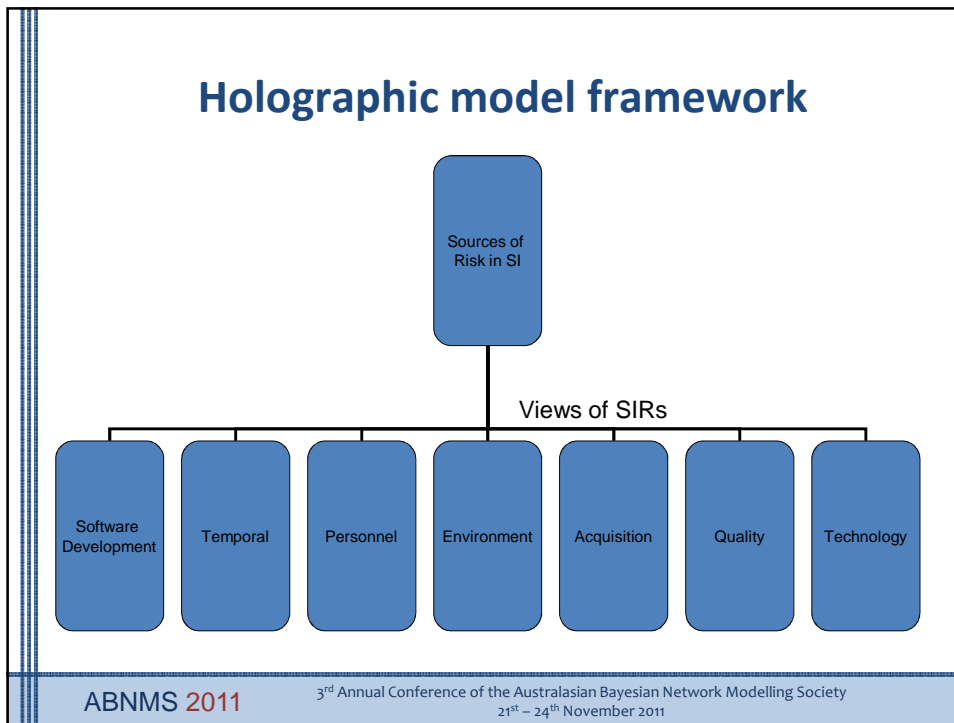
- Problem definition and significance
- Background: systematic view of SI risks
- Desired modelling objectives and characteristics
- Model design and development process
  - Model modules, topology, usage of idioms
- Expert knowledge elicitation process, combine methods
- Hybrid Model prototype description
- Suggestions for further research and model improvement

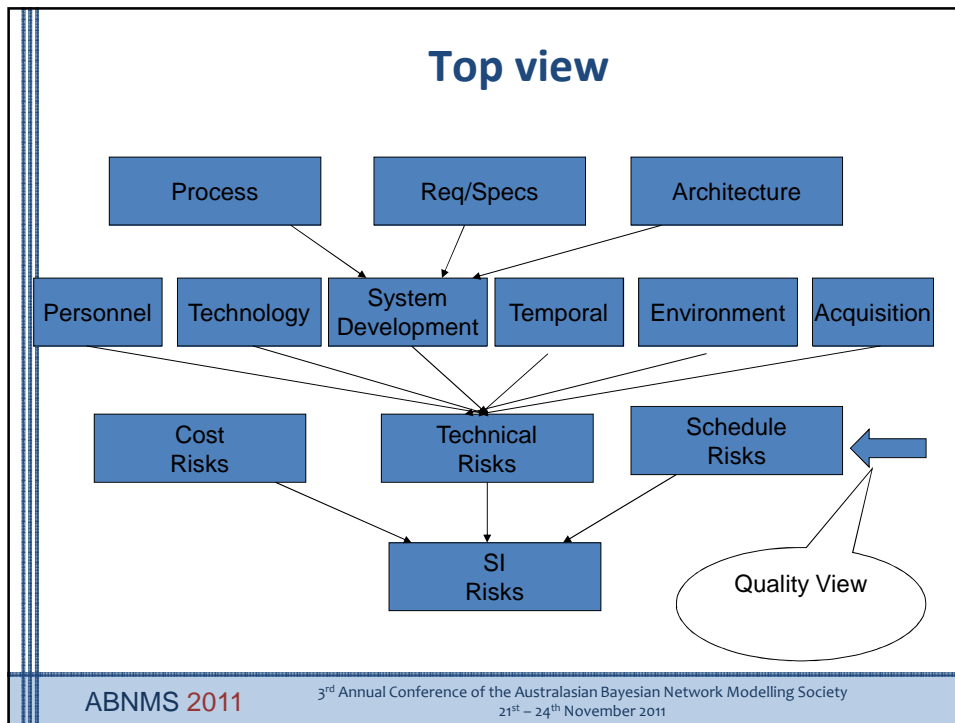
### **Problem definition and significance**

- The systems integration is a process when the first time fully engineered components and subsystems are linked to each other and made to perform as a unified functional entity.
- Integration risks manifest themselves in later stages of a program.
- Lack of effective tools to measure and categorize this risk early in a program's life cycle.
- The current trend: the system becomes more hardware-software-human interactive.
- The integration problems are significant today and if they are not adequately addresses they will present tremendous problems in the future (B.Boehm 2007).

### **Background: systematic view of SI risks**

- Research has been done in relation to system integration risks identification and presentation
- The potential risk factors affecting SI process were identified and analysed
- Hierarchical Holographic modelling methodology was adopted to capture diverse characteristics of SI process.





## Modelling objectives for SITR model

- Develop modular and extendable approach for system integration risk assessment modelling
- Acquire domain knowledge and expertise available in Australian Defence and Industry
- Develop executable BBN prototype (tool) to demonstrate applicability of the suggested approach

## Modelling approach: Dealing with Risks and Uncertainty

- Uncertainty inherent to every aspect of system/software development including requirement specifications, design, coding, integration and testing.
- Sitr modelling requires the inferring the probabilities of events which have not yet been observed.
- Sitr modelling requires making prediction with incomplete data.
- Sitr modelling requires combining diverse types of evidence including subjective beliefs and objective data.
- Sitr modelling includes complex inference chains where Sitr probabilistic inference involving features are not related directly to each others.

## BBN benefits for Sitr assessment

- BN provides a formal mechanism for recording and testing subjective information.
- BN is able to explicitly quantify the uncertainty.
- BN provides a mechanism for sensitivity analysis by it's capability to reasoning from cause to effect and backwards.
- BN provides a mechanism for updating the belief about unknown factors known as the posterior probability distribution based on the observed evidence.
- Make possible the prediction with incomplete data.
- The graphical language of BNs makes it easier to understand and explain the causality.

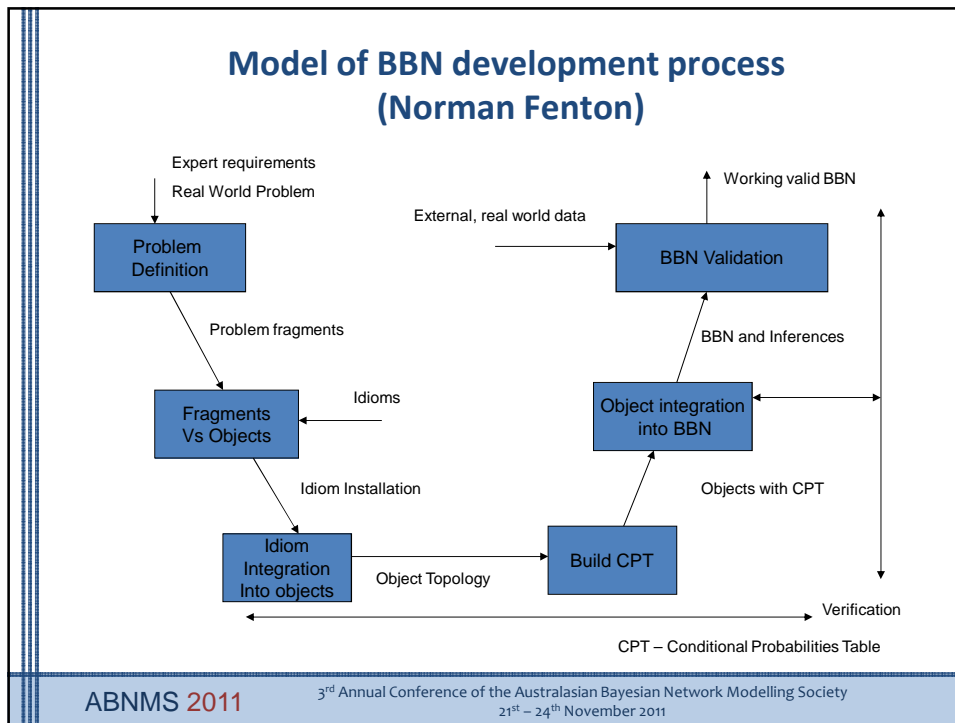
## Building a complete BN

- Build Graph Topology from logical fragments
- Define the node probability tables for each node
- Reconciling fragments into one single model
- Incorporate diverse evidence to improve an assessment
- Validate the model

## SITR Model design steps

The SIR model design and BN development process involves three main steps:

- Step 1) Identify the variables (particular risk SIR factors) that are of importance, along with their possible state values.
- Step 2) Identify the relationships between the variables and express them in a graphical structure.
- Step 3) Define and access the probabilities required for its quantitative part.



## Model Topology

Final SITR model is represented by a large scale BBN network.

We use modular technique by:

- Building initially separated fragments or BN modules (constructed and reasoned about independently) and
- Reconciling them into one single model at the final stage.

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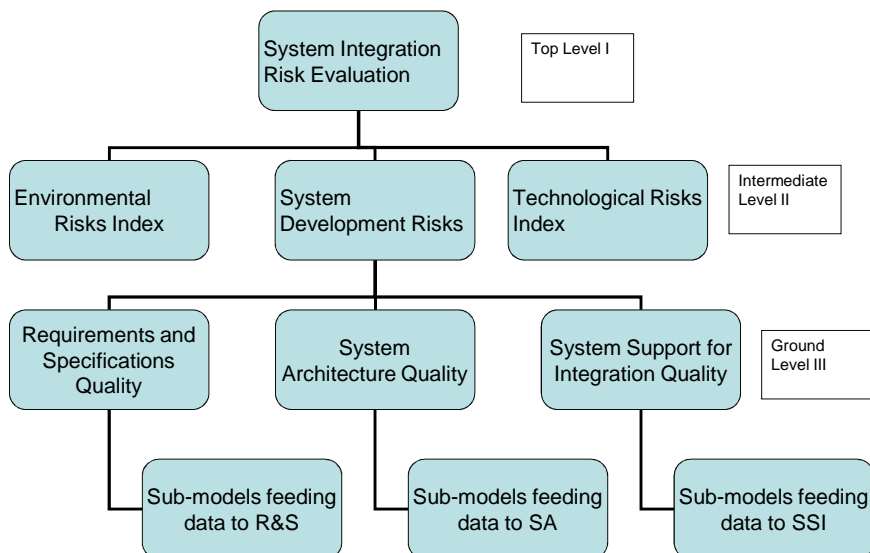
### BBN Proposed Hierarchy

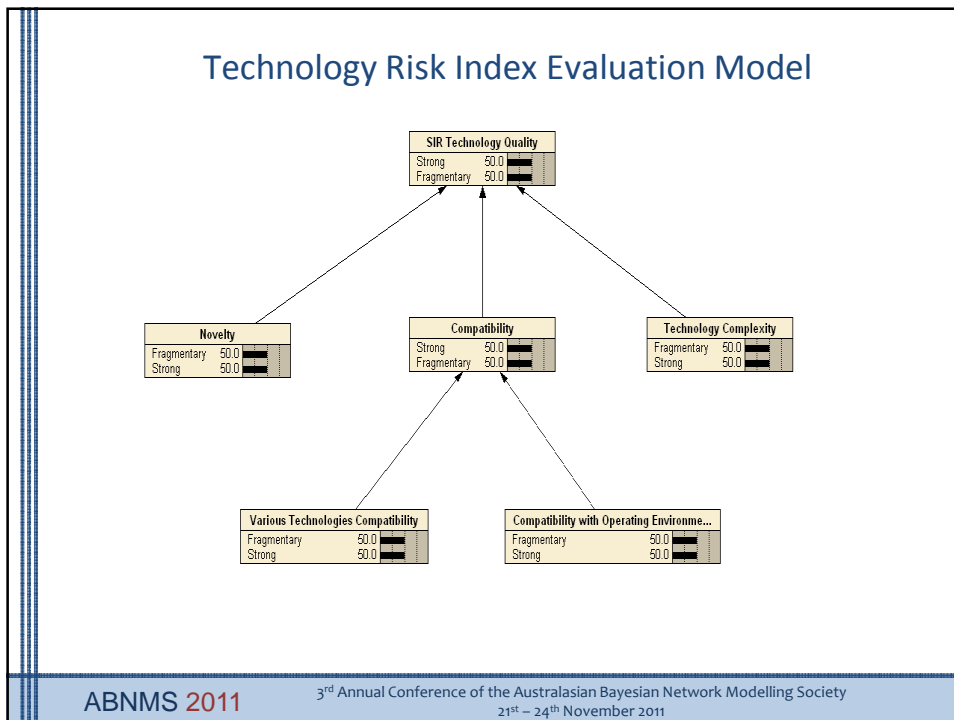
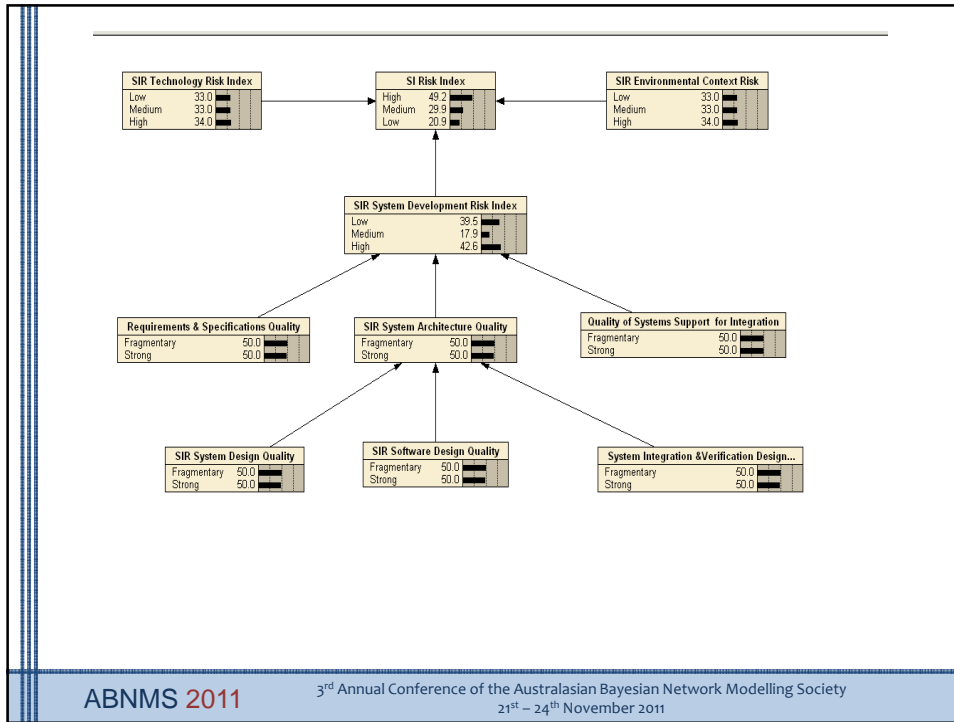
- Top Level – Consolidated Conceptual BBN, representing generalised domain influence on outcome distribution
- Intermediate Level – Domain specific conceptual level, representing domain specific concepts and their influences on the elements of the Top level.
- Ground (bottom) Level - Directly (and indirectly) measured domain characteristics and factors clarifying conceptual elements of the Intermediate level.

The first two are completely implemented as BN models.

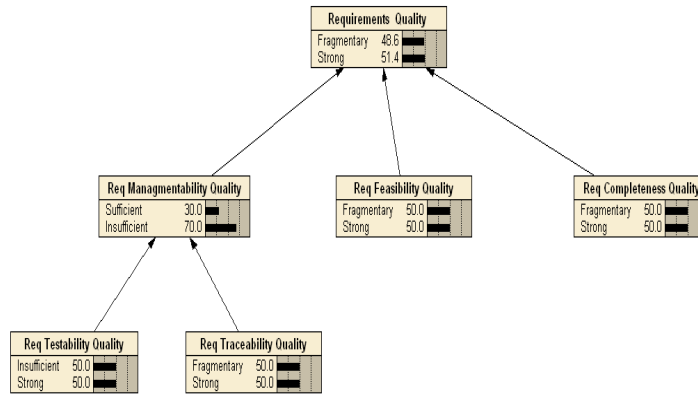
The third level has hybrid implementation as BN and parametric models for values calculation, used as evidence or input parameters in the second level.

### BN model logical hierarchy

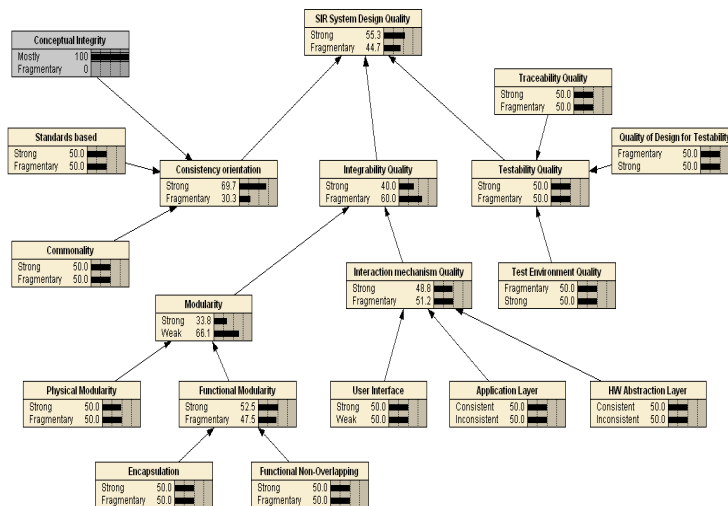


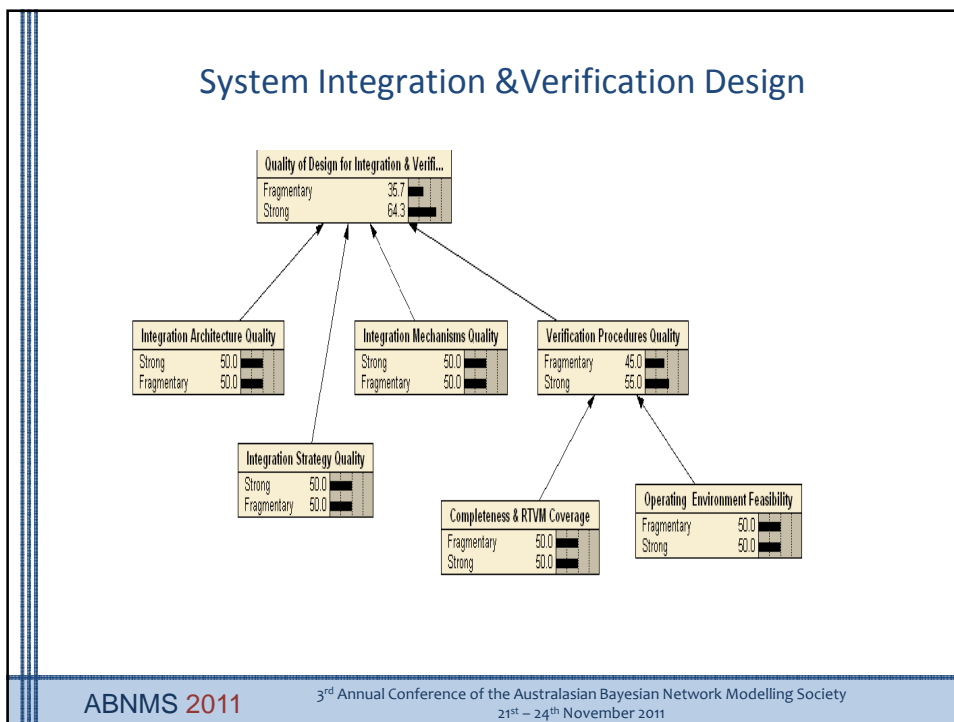
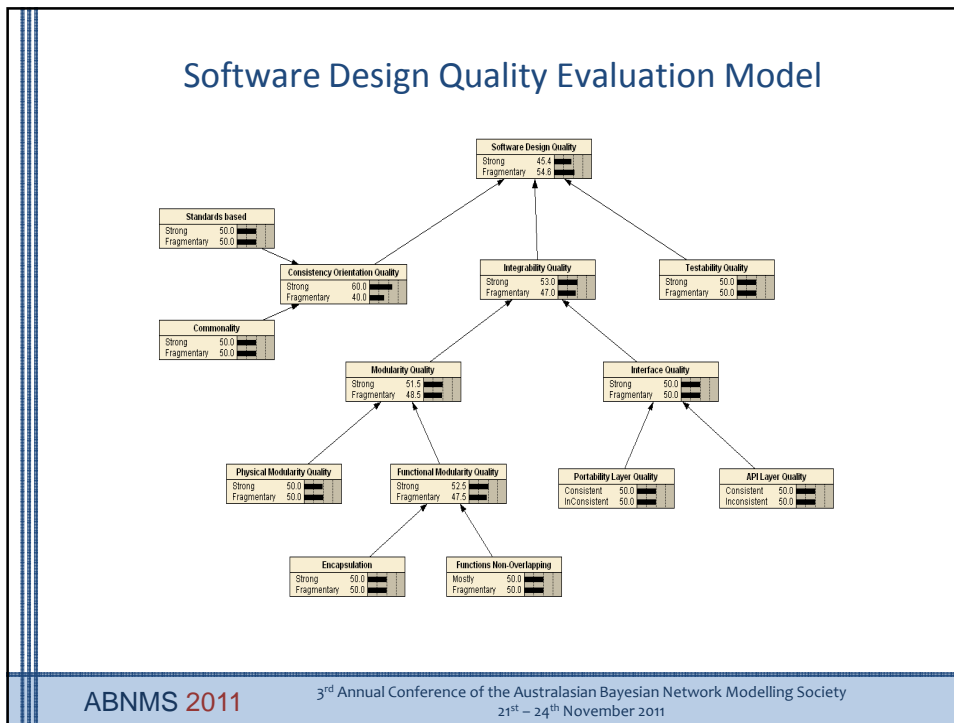


## Requirements & Specifications Quality evaluation



## System Design Quality Evaluation Model





## Quantifying BN

Obtaining numerical probabilities still present a major “obstacle” in BN building process.

Includes 2 steps:

- data acquiring, expert knowledge elicitation (available in many different shapes)
- method of utilising this data – encoding into probabilities

To overcome this issue we propose having a hybrid model consisting of two linked sub-models:

- Generic BBNs, representing relations between conceptual risks
- Parametric Models, representing evaluation of risks related to a particular case.

## Elicitation methods

- **Frequency Estimation**  
Stating probability elicitation questions in frequency format
- **Gamble Methods**  
Probabilities are determined by using gamble-like methods
- **Hierarchical Methods**
  1. elicit information to limit the set of possible joint probability distribution
  2. derive second-order probability distribution
- **Using Multiple Experts**
  1. Individual assessments
  2. Aggregating probabilities
  3. Expert consensus

## Combined technique for elicitation process

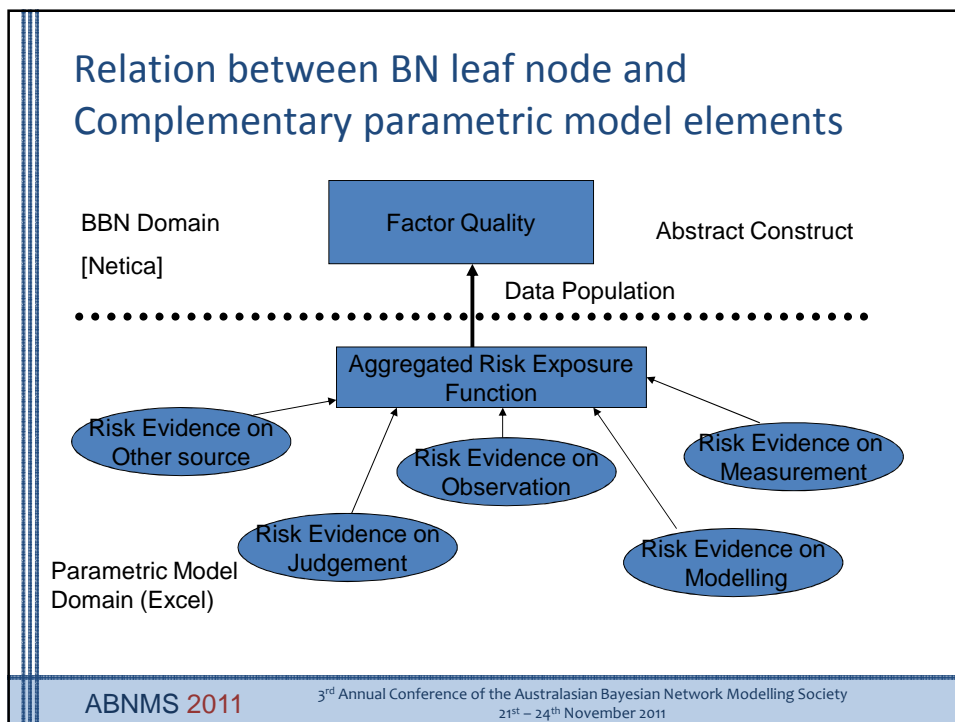
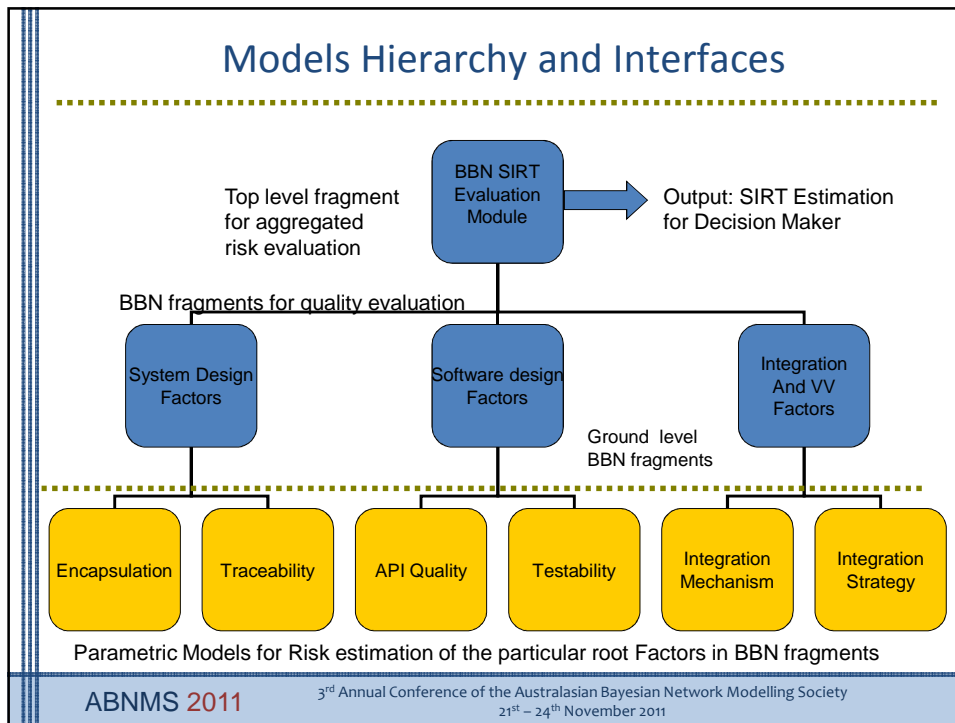
Propose to use the hybrid methodology which combines BN and Indicators Rating technique.

Propose to extend BN model with complementary parametric model based on Indicators Rating concept [Boehm Early Identification of SE-Related Program Risks 2009]

- Each leaf node of BNs will have an associated Parametric model
- Each parametric model will consist of a set of success Indicators (represented as question to experts)
- Parametric model will calculate aggregated input value to feed the leaf node with project specific data for SIR assessments

## Knowledge representation in the models

- There are two different formats for knowledge representation in the suggested SIR tool:
  - BN node's Conditional Probabilities Tables. They represent expert knowledge in term of generic relations between abstract constructs and do not depend on a particular project
  - Expert Indicators ratings. They reflect expert knowledge in terms of evaluation of indicator's influence onto SIR in a particular project context. They are prime input data for SIR assessment of a particular project



## Parametric model structure

### Design for Testability Factor:: BBN System Design

**Design for Testability Factor::** automatically calculated Risk level: **Low**

**Question 1: Rate evidence found in the design documents of the acceptable capabilities and good quality of build-in tests.**

Expert rating degree of evidence as **Strong**, Partial, Weak, Little-No

Expert rating consequences or risk impact as Critical, **Significant**, Moderate, Little-No

Tool automatically calculates risk exposure or level as high, medium, **low**, very low

**Question 2: Rate evidence of technical testers and integrators teams stability during design project phase?**

Expert rating degree of evidence as Strong, Partial, Weak or Little-No

Expert rating for consequences or risk impact as Critical, Significant, Moderate or Little-No

## Suggestions for further research and model improvement

- Model refining and CPT granularity improvements
- Design questionnaire for SI risk assessment sub-models
- Conduct expert knowledge elicitation
- Process collected data and realign CPT values
- Conduct model sensitivity analysis to identify most influential factors affecting SI risk
- Extensive literature search for relevant and credible statistical data for BN verification
- Convey modelling results to expert community to seek their model assessment for verification



Questions?

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