SOCIETY OF ACTUARIES

ERM Symposium
April 2010

1B: Identification of Emerging Risk Using Bayesian Conditional Probability

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EMERGING RISKS
ERM SYMPOSIUM – APRIL 2010

Risk and Insurance Management Society (RIMS)

- Founded in 1950
- Membership:
  - Over 4,000 member entities
  - USA, Canada, Mexico, and Japan
  - Over 10,500 risk professionals
- Vision:
  - The Risk and Insurance Management Society will be the global leader in all aspects of risk management
  - Leadership, Education, Standards

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CHARACTERISTICS OF EMERGING RISKS

Characteristics of Emerging Risks

- •High Uncertainty
- •Lack of consensus
- •Unknown relevance
- •Difficult to communicate
- •Difficult to assign ownership, and
- •Hard to quantify

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ERM as defined by RIMS

Enterprise Risk Management ("ERM") is a strategic business discipline that supports the achievement of an organization's objectives by addressing the full spectrum of its risks and managing the combined impact of those risks as an interrelated risk portfolio. ERM represents a significant evolution beyond previous approaches to risk management in that it:

1. Encompasses all areas of organizational exposure to risk (financial, operational, reporting, compliance, governance, strategic, reputational, etc.);
2. Prioritizes and manages those exposures as an interrelated risk portfolio rather than as individual "silos";
3. Evaluates the risk portfolio in the context of all significant internal and external environments, systems, circumstances, and stakeholders;
4. Recognizes that individual risks across the organization are interrelated and can create a combined exposure that differs from the sum of the individual risks;
5. Provides a structured process for the management of all risks, whether those risks are primarily quantitative or qualitative in nature;
6. Views the effective management of risk as a competitive advantage; and
7. Seeks to embed risk management as a component in all critical decisions throughout the organization.

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RIMS Efforts in Emerging Risks

- ERM Development Committee
  - Center of Excellence including tools, library, etc.
  - Established emerging risks sub-committee of risk practitioners focused on research and thought leadership
  - Releasing Emerging Risks whiter paper to be released at 2010 RIMS in Boston
  - Focus is on practical tools and guidance for risk managers in companies of all sizes
  - Generally seek an "open-source" approach to common risk management problems.

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A FEW EXAMPLES

EMERGING RISK EXAMPLES

- #1 –Organized crime and data incursions
- #2 – Swine Flu – H1N1
- #3 – Kodak and the development of digital cameras

EMERGING RISK EXAMPLE #1

- Description of risk
  - Organized crime and data incursions Breach Type: Source- www.datalossdb.org
- Development of the risk
  - Growth of data breaches Incidents Recorded – U.S. Only (http://www.privacyrights.org/ar/ChronDataBreaches.htm)
  - Timeline
    - Rapid increase in since 2006
- Challenges presented
  - Evolution of methodology
  - Quantifying the potential losses and frequency of losses

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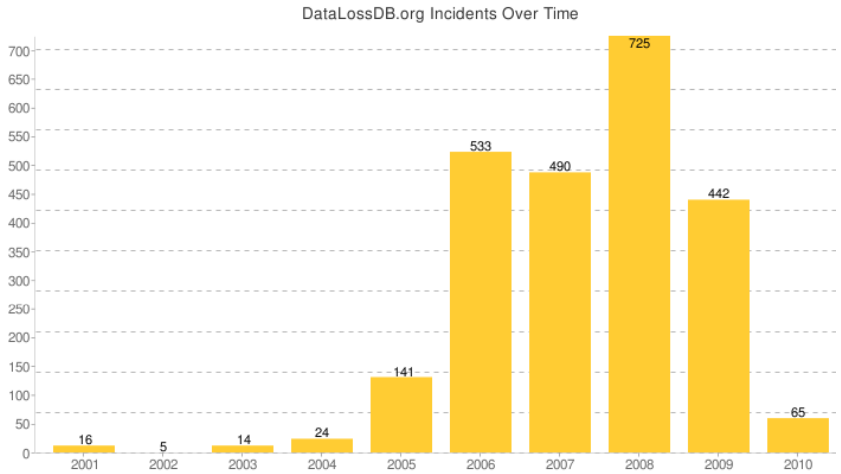
INCIDENTS RECORDED – U.S. ONLY



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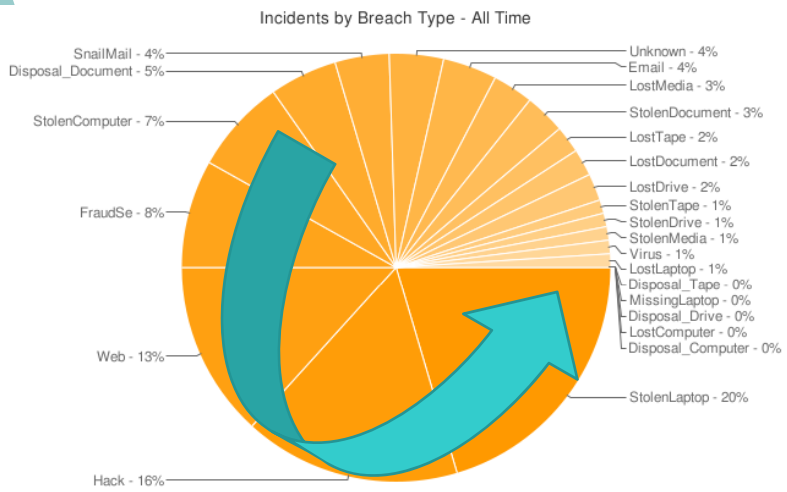
BREACH TYPE: SOURCE-WWW.DATALOSSDB.ORG



KEY DEVELOPMENTS

- Incidents are increasing
- Not all are reported (and often may not be known for some time, if ever)
- Criminal elements are actively using this methodology as a relatively safe option

According to Symantec (http://www.symantec.com/norton/cybercrime/definition.jsp)

- Cybercrime has surpassed illegal drug trafficking as a criminal moneymaker.*
- Every 3 seconds an identity is stolen.**
- Without security, your unprotected PC can become infected within four minutes of connecting to the internet.***

*"Cybercrime More Profitable Than Drugs", NineMSN, More Info.

**Identity Theft Statistics, Identity Protection Online, More Info.

***"Eliminating Mobile Security Blindfolds", Tech News World, More Info.

EMERGING RISK EXAMPLE #2

- Description of risk
  - Previously unknown version of potentially lethal flu virus with ability to cross species.
- Characteristics
  - Limited natural immunity,
  - Rapid dispersal,
  - High mortality rate
- Development of the risk
  - Timeline: rapid development from February to May of 2009.

- Challenges presented
  - Action / Reaction? School closings, Mexico shutdown, parents pulling kids out of school
  - Quantifying the potential magnitude of losses and frequency and timing of losses

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EMERGING RISK EXAMPLE #3

- Description of risk
  - Kodak and the development of digital cameras
- Characteristics
  - Pioneer in field of silver-based photography
  - Lead in introduction of key developments in traditional photography
    - Kodak Brownie camera
    - Kodak film
      - Black and white films (High speed and low speed)
      - Color prints
      - Color slide film

- Development of the risk
  - Timeline: Rapid changes in mid-1990s…significant amount of the population has no idea what film is….
- Challenges presented
  - Action / Reaction? New products. Cult following. Not enough
  - Quantifying the potential impact of strategy changes and spe market changes

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EMERGING RISKS AND BAYESIAN APPROACH

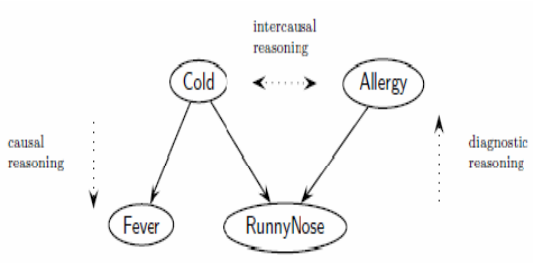
What is Bayes' Theorem?

- The **Bayesian** view of probability is related to degree of belief. It is a measure of the plausibility of an event given incomplete knowledge.

$$P(A|B) = \frac{P(B|A)\,P(A)}{P(B)}.$$

- Bayes' theorem was derived from the work of the Reverend Thomas Bayes – a 17th century British mathematician
- Statistical inference in which evidence or observations are used to update or to newly infer the probability that a hypothesis may be true
- Hypotheses with very high support of evidences should be accepted as true and those with very low support should be rejected as false

Introduction to Basics of Bayesian Belief Networks



- Causal networks support
  - causal and diagnostic reasoning (also known as deductive and abductive reasoning, respectively)
  - intercausal reasoning (explaining away):
    - Observing Fever makes us believe that Cold is the cause of RunnyNose, thereby reducing significantly our belief that Allergy is the cause of RunnyNose

Advantages of Bayesian Approach

- Rationality – AC (Affirming the Consequent) & DA (Denying the Antecedent) fallacies
- Use of expert judgment in a robust statistical tool
- Transparency

Advantages of Bayesian Approach

- A framework for *explaining* cognition.
  - How people can learn so much from such limited data.
  - Strong quantitative models with minimal ad hoc assumptions.
- A framework for understanding how structured knowledge and statistical inference interact.
  - How simplicity trades off with fit to the data in evaluating structural hypotheses (Occam's razor -... "**when you have two competing theories that make exactly the same predictions, the simpler one is the better**.")
- Bayes' rule tells us how to combine prior beliefs with new data
  - top-down and bottom-up influences
- As a model of human inference
  - predicts conclusions drawn from data
  - identifies point at which prior beliefs are overwhelmed by new experiences

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Challenges of Bayesian Approach

- Computing power
  - Now largely overcome through
    - More powerful & cheaper computers
    - The use of Commercial software packages:
- Incorporating Expert Opinion
  - Needs to be done carefully
  - Clear framing of the issue is necessary
  - Anchoring to most recent events/scenarios is a common problem
  - Easier if a large network is broken down into smaller and simpler networks

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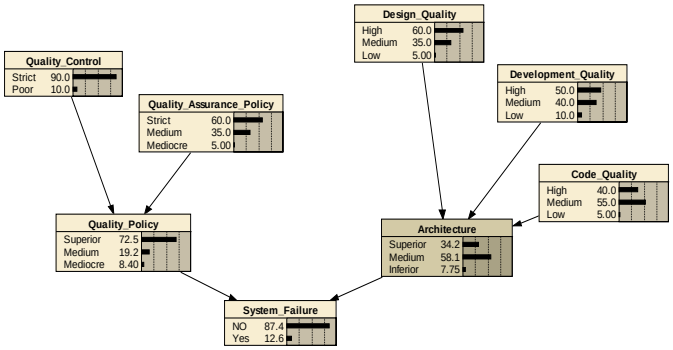
Summary of Bayesian Tools

- Hugin
- Agena Risk
- Netica
- Bnet.builder

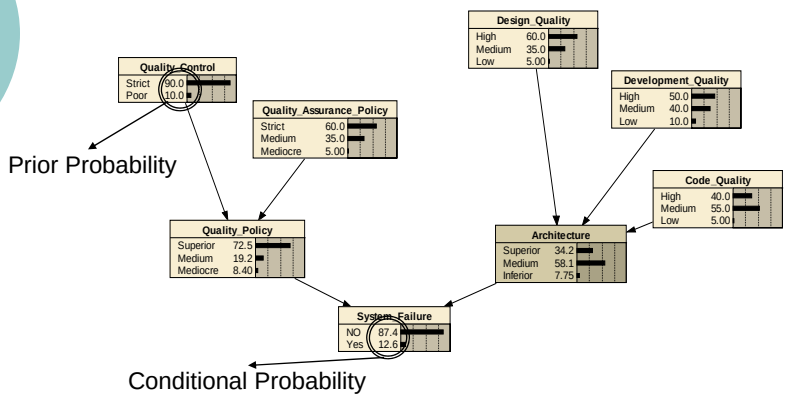
Kevin Murphy (Berkley University) maintains a website that provides an excellent introduction to Bayesian Belief Networks (BBNs). The site also contains links to relevant web literature on BBNs.
http://www.ai.mit.edu/~murphyk/Bayes/bnintro.html
Norman Fenton (London University) has developed a very helpful online tutorial on the theory and development of BBNs.
http://www.dcs.qmul.ac.uk/~norman/BBNs/BBNs.htm
Russell Greiner (University of Alberta) maintains a website that provides links to numerous articles, research groups, software, and applications associated with BBNs.
http://www.cs.ualberta.ca/~greiner/bn.html
Amos Storkey (University of Edinburgh) also maintains a useful website on BBNs
http://www.anc.ed.ac.uk/~amos/belief.html

A Practical Example

Operational Risk of an IT System - Initial Analysis

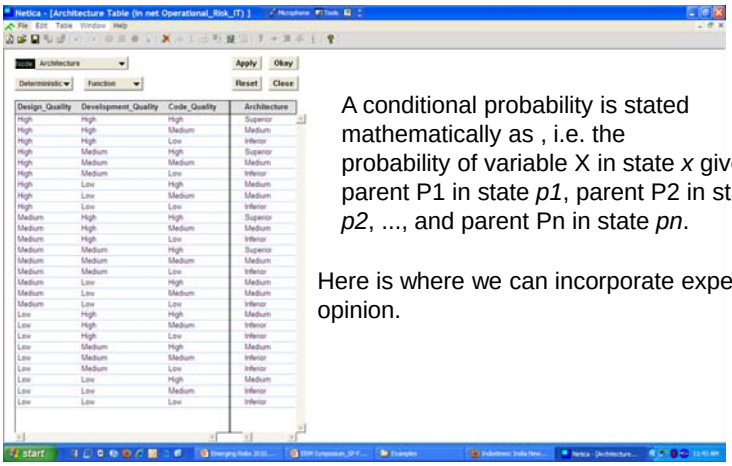


Initial Analysis – Stage 1



The probability of failure at 12.6% is within the tolerance limit Set at 15%

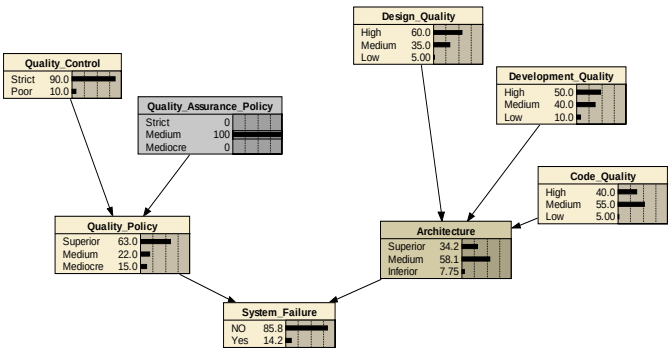
Conditional Probability Table



A conditional probability is stated mathematically as , i.e. the probability of variable X in state *x* given parent P1 in state *p1*, parent P2 in state *p2*, ..., and parent Pn in state *pn*.

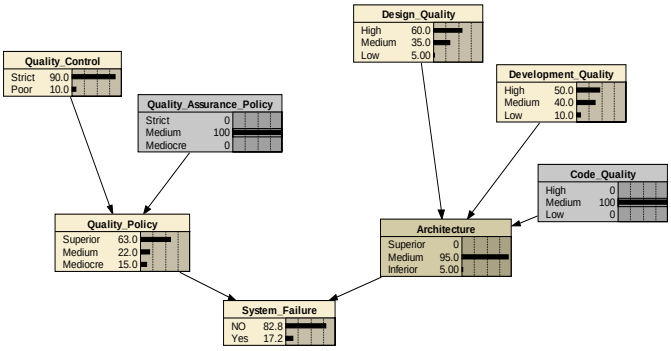
Here is where we can incorporate expert opinion.

Stage 2



The policy now has been made a little lax. The probability of system failure now creeps up to 14.2% - still within the tolerance limit.

Stage 3



Now if the best programmer quits. The probability of failure is now 17.2% - it is higher than the tolerance limit.

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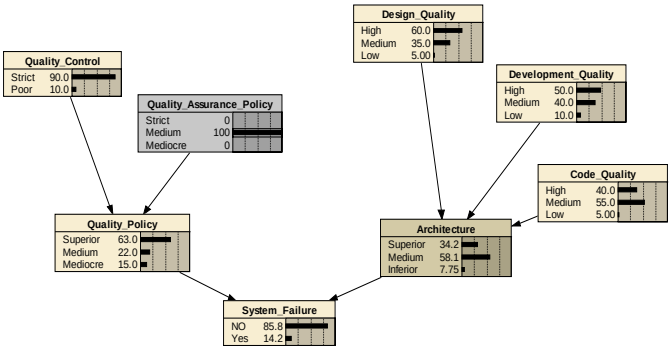
Stage 2



Emerging risk – when the policy failed to be strict, at the independent variable level it was not a big change. At the dependent variable level, the impact was not significant – still less than the tolerance limit.

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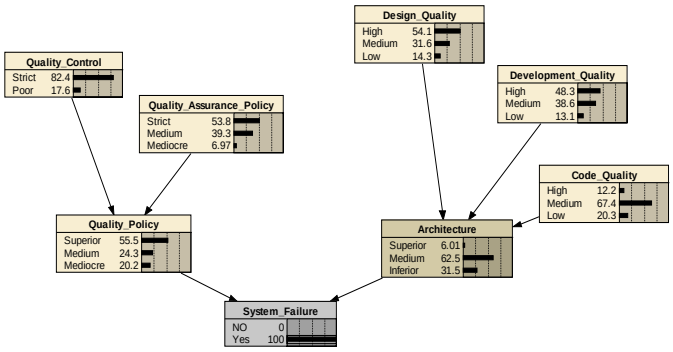
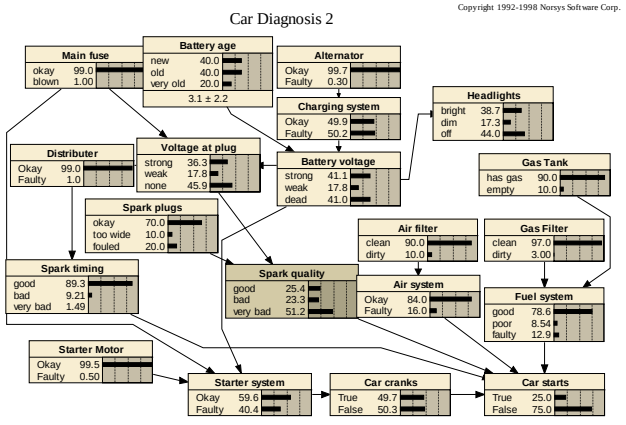
Backward Propagation



Example of Complex Networks



CONCLUSION AND QUESTIONS

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