A Bayesian Network for
Predicting Defect Correction Costs

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Engineering Systems Radar
Background & Motivation

- Today's readmission rate for cars is ~ 70,000,000 cars per year
- Average of 20 to 70 embedded systems per car
- 50% development effort spend on software engineering
- Every 2nd car recall caused by software problems
- Software defect prediction plays an important role in customer satisfaction and overall cost reduction
Software Process Model (SPM) 1/2

- External models did not fit to our processes and data
- Created company specific model (SPM)
- Change model as a Dynamic Bayesian Net
- Calibration based on internal data
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Dataset

- 259 data points, each reflects a single Change of
  - Change & Defect Management system
  - 17 defect correction (Bugfix) entries
  - 242 development entries

- Focus on the distribution of tasks
  - ~14 Changes per defect

**BUT:** What does a single defect mean?
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Dataset (revised)

Focus on effort for development and defect correction
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Defect Cost Factor (DCF)

→ DCF = Defect Correction Effort / Development Effort

![Bar chart showing DCF for different systems]

- CAN: DCF = 0.0840
- HMI: DCF = 0.1137
- PAD: DCF = 0.0260
- VDB: DCF = 0.0053
- CNV: DCF = 0.0063
Software Process Model (SPM) 2/2

- External models did not fit to our processes and data
- Created company specific model (SPM)
- Change model as a Dynamic Bayesian Net
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**BUT**: Optimization potential was too low!
Defect Flow Model

- Defect Flow Model
  - Focus on number of defects
  - Over development phases

- Local optimization
  - Phase specific

- Focus on overall process missing
  - What happens when defects shift over phases?

<table>
<thead>
<tr>
<th>Number of Defects</th>
<th>RE</th>
<th>DE</th>
<th>IM</th>
<th>I&amp;T</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>-47</td>
<td>-119</td>
<td>-119</td>
<td>-98</td>
</tr>
<tr>
<td>8</td>
<td>125</td>
<td>21</td>
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<td>25</td>
</tr>
<tr>
<td>-7</td>
<td>28</td>
<td>12</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>-9</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
<td>-10</td>
</tr>
<tr>
<td>-21</td>
<td>-19</td>
<td>-19</td>
<td>-19</td>
<td>-19</td>
</tr>
</tbody>
</table>
Introducing

- Defect Correction Effort
- Phase Multiplier
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Defect Cost Flow Model 2/2

Requirements Engineering (RE)
- DCE After QA

Design (DE)
- DCE
- Phase Multiplier
- DCE After QA

Implementation (IM)
- DCE
- Phase Multiplier
- DCE
- Phase Multiplier
- DCE After QA

Integration & Test (I&T)
- DCE
- Phase Multiplier
- DCE
- Phase Multiplier
- DCE
- Phase Multiplier
- DCE After QA
Scenario Simulation

- S1 is at low QA activities, the worst case scenario
- S2 uses a high amount of QA effort typically used
- S3 has very high QA activities focusing on RE and DE
- S4 uses very high QA activities on all development phases

<table>
<thead>
<tr>
<th>Result</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
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<tbody>
<tr>
<td>Development effort</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
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<tr>
<td>QA effort</td>
<td>50</td>
<td>200</td>
<td>320</td>
<td>400</td>
</tr>
<tr>
<td>DCE (part of QA)</td>
<td>1224</td>
<td>2343</td>
<td>1328</td>
<td>1608</td>
</tr>
<tr>
<td>Residual DCE</td>
<td>9771</td>
<td>528</td>
<td>457</td>
<td>177</td>
</tr>
<tr>
<td>Overall</td>
<td>12045</td>
<td>4071</td>
<td>3105</td>
<td>3185</td>
</tr>
</tbody>
</table>
Conclusion

- Defect Cost Flow model enables
  - Process wide optimization
  - Focus on defect correction effort
  - Incorporating phase specific effort multipliers
  - Results in focus on early development phases

- Increase product quality and customer satisfaction

- Bayesian Networks can support decision makers

- Ideal method to monitor process improvement and learn from it
Thank you!
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Chassis Systems Control

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