Self-managing Networks, is Reality Today?

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Motivation

- Why is self-management important in the first place?
  
  It is not possible to achieve scalability without first achieving self-management; a large-scale distributed system will otherwise be completely unmanageable.
The Reality

How well-equipped is your network for the business challenges you face over the next two years?

<table>
<thead>
<tr>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Our network is well equipped for all the business challenges we face</td>
<td>6%</td>
</tr>
<tr>
<td>Our network is well equipped for most of the business challenges we face</td>
<td>32%</td>
</tr>
<tr>
<td>Our network is well equipped for some of the business challenges we face</td>
<td>47%</td>
</tr>
<tr>
<td>but not all of them</td>
<td></td>
</tr>
<tr>
<td>Our network is well equipped for only a few of the business challenges we</td>
<td>11%</td>
</tr>
<tr>
<td>face</td>
<td></td>
</tr>
<tr>
<td>Our network is not equipped for the business challenges we face</td>
<td>4%</td>
</tr>
</tbody>
</table>

Source: AT&T/Economist Intelligence Unit Networking and Business Strategy Survey, March-April 2004
Self-Managing Networks

- **Aspects of the networking environment**
  
  Several heterogeneous and loosely coupled systems
  
  Fixed and wireless communication links
  
  Changing components, workloads, demands, and external conditions as well as device failure, loosely said, hardware and software failures
Self-Managing Networks

- **Aspects of self management**
  - Absence of external control (autonomy)
  - Dynamic operation (time evolution)
  - Fluctuations (workload and network structure)
  - Symmetry breaking (heterogeneity)
  - Global order (emergence from local interactions)
  - Instability (self-reinforcing choices/nonlinearity)
  - Multiple equilibria (many possible attractors)
  - Redundancy (insensitivity to damage)
  - Self-maintenance (repair/reproduction metabolisms)
  - Adaptation (functionality/tracking of external variations)
  - Complexity (multiple concurrent values or objectives)
The Golden Formula

\[ v_f = Bv_{out} \]

\[
\frac{v_{out}}{v_{in}} = \frac{A}{1 \pm AB}
\]
The Golden Formula

- A feedback loop consists of
  1. The detection of an anomaly,
  2. The calculation of a correction, and
  3. The application of the correction.
The Golden Formula

- Nonlinearity

- Self-management is a grand challenge that reaches far beyond a single organization.
  
  Standardisation
  
  Resource/service description
  
  Service negotiation
  
  Reasoning
<table>
<thead>
<tr>
<th>Aggregation</th>
<th>Advisory</th>
<th>Lower-level Decision</th>
<th>Higher-level Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too much information anyway</td>
<td>War is too important to be left to the generals</td>
<td>Tight and well defined algorithms</td>
<td>Would that ever come true?</td>
</tr>
</tbody>
</table>