Developing operational profile

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So far

SRE Ideas

- Focus resources on the most critical/used functions
- Process used throughout the life-cycle
- User oriented, rather than system oriented
- Necessary reliability defined early in the life-cycle
- **Make testing realistically represent field conditions**
  - How will users realistically deploy this product
Concepts: Operation

- A major logical task performed by the system, short in duration
- Returns control to the system when completed
- Substantially different than other operations
- **Major**: Related to a functional requirement, or a product feature (not a subtask). May contain several subtasks.
- **Logical**: May span software, hardware and human interactions
- **Short duration**: 100’s or 1000’s per hour (usually)
- When an operation is completed, it frees system resources, which can be used by (a competing) operation
- **Substantially different**: High probability of containing a fault not detected in (by) other operations
Operations

Exact meaning of substantially different?

- On the average (use caution) 6 faults per 1000 execution lines of source code at the beginning of system level testing
- ==> 0.6 faults per 100 LOC
- ==> 100 LOC may represent a substantially different operation
- Therefore, test each operation AT LEAST once.

Operation initiated by a user, another system, system’s controller
Examples

- User executes a command (send an e-mail message)
- Response to an input from external system
  - Processing of a transaction (purchase, reservation)
  - Processing an event (interrupt, alarm, mechanical movement observed through sensor,...)
- Routine housekeeping
  - File backup, security audit, database cleanup...
Application Description: Fone Follower (FF)

- Subscriber calls FF, enters planned phone numbers (forwardees) to which calls are to be forwarded (over time).
- FF forwards incoming calls (voice, fax) from network to subscriber. Incomplete voice calls go to pager (if exists), then to voice mail.
- Base product for US market, variation for Japan.
- Subscribers view this service as a combination of standard phone service with call forwarding.
A complete set of operations and their corresponding occurrence probabilities.

Tabular representation

<table>
<thead>
<tr>
<th>Operation</th>
<th>Operations per hour</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice call, no pager, answer</td>
<td>18,000</td>
<td>0.18</td>
</tr>
<tr>
<td>Voice call, no pager, no answer</td>
<td>17,000</td>
<td>0.17</td>
</tr>
<tr>
<td>Voice call, pager, answer</td>
<td>17,000</td>
<td>0.17</td>
</tr>
<tr>
<td>Voice call, pager, no answer</td>
<td>16,500</td>
<td>0.165</td>
</tr>
<tr>
<td>Fax call</td>
<td>15,000</td>
<td>0.15</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Total</td>
<td>100,000</td>
<td>1</td>
</tr>
</tbody>
</table>
Graphical representation

operation is a path in a graph (tree)

To find probability of an operation multiply probabilities along the path leading to it.

Private branch exchange (PBX) system:

<table>
<thead>
<tr>
<th>Dialing type attribute</th>
<th>Call destination attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard = 0.8</td>
<td>External = 0.7</td>
</tr>
<tr>
<td>Abbreviated = 0.2</td>
<td>Internal = 0.3</td>
</tr>
</tbody>
</table>
<pre><code>            | External = 0.1              |
            | Internal = 0.9              |
            |                             |
</code></pre>
Operation mode

- Distinct pattern of system use
- Environmental conditions needing separate testing because likely to stimulate different failures
- We need an operational profile for each distinct operational mode
  - Operations may be the same, but their probabilities will be different
- System operational profile: Complete set of operations for the system and probabilities of occurrence based on all operation modes.
Developing an OP

- Testers must be capable of developing operational profiles.
- If marketing and management personnel communicate with expected users, they should develop operational profiles.
  - Recommendation: system testers/architects/engineers should participate in meetings with customers.
- Initial versions of operational modes and their operational profiles must be developed early.
  - This allows allocation of performance, cost, priorities
  - Reduced operation development (ROS): implement most used/critical operations first!!!
  - Software analog of RISC architectures.
Determine the operational modes.
- Often the same for product/variants/supersystems.

Determine operational profile for the system across operational modes, then for each operational mode.

To develop an operational profile:

1. Identify the initiators of operations.
2. Choose tabular/graphical representation.
3. Create operations list for each initiator.
4. Determine the occurrence rate of each the individual operations and/or their corresponding attributes.
5. Determine occurrence probabilities (operations, attributes).
Determining operational modes

- Use engineering judgement, do not go to a too low level of details

- Contributing factors:
  1. Day/time (prime vs. off hours)
  2. Time of the year (end of fiscal year, calendar year)
  3. Traffic levels
  4. Different user types (user profiling)
  5. User experience (experts, novices)
  6. System maturity
  7. Reduced system capability (depending on the development phase)
Example: Operation modes

- A telephony system:
  - Peak hours: Heavy calls and entries traffic, no administration* or audit** operations executed
  - Prime hours: Average calls and entries traffic, some admin, but no audit executed
  - Off hours: low calls and entries traffic, low admin, extensive execution of audit operations

- If the system handles internet providers, how would this be reflected in operational modes?

* for example, add or delete customers
** Check database integrity, unusual calling card patterns...
Identifying operation initiators

- System users, external systems, controllers (admin)
- Identify users by studying the business case
- *Customer type:* those who have similar business profile
- *User type:* individuals who use the product (on-line, not manager reading a report), correlated with job roles.

- Telephony system users:
  Subscriber, sysadm, *telephone network*, system controller
Graphical vs. Tabular

- Tabular better when the number of attributes is small
- Operations characterized by sequences of events (steps) suitable for graphical representation
- Combination of both is practical
Creating operations list

- Divide task by operation initiators. Most of these are human, so it is easier to comprehend the system.
- Consult system requirements and additional resources
  - Process flow diagrams, draft manuals, prototypes, earlier versions.
- Discussions with “typical users”
- If automation of manual tasks, speak with people doing the work manually
- Menu driven programs: walk the menu tree!
- Maintain traceability: requirements vs. operations
### Fone follower, once again

<table>
<thead>
<tr>
<th>Operation initiator</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subscriber</td>
<td>Phone no entry (forwardees)</td>
</tr>
<tr>
<td>System administrator</td>
<td>Add subscriber</td>
</tr>
<tr>
<td></td>
<td>Delete subscriber</td>
</tr>
<tr>
<td>Telephone network</td>
<td>Process voice call, no pager, answer</td>
</tr>
<tr>
<td></td>
<td>Process voice call, no pager, no answer</td>
</tr>
<tr>
<td></td>
<td>Process voice call, pager, answer</td>
</tr>
<tr>
<td></td>
<td>Process voice call, pager, answer on page</td>
</tr>
<tr>
<td></td>
<td>Process voice call, pager, no answer on page</td>
</tr>
<tr>
<td>System controller (FF)</td>
<td>Process fax call</td>
</tr>
<tr>
<td></td>
<td>Audit section of a phone no database</td>
</tr>
<tr>
<td></td>
<td>Recover from hardware failure</td>
</tr>
</tbody>
</table>
Operations list

- Cost of developing operational profile heavily affected by the number of identified operations (~50)
- If 1000+: Develop additional operational modes and stratify operations in modes
- Typical cost of OP development: 0.5 staff_hour/operation
- Limit collection of occurrence probabilities to higher use operations
- Do not forget to adjust operational profiles with new releases
  - Especially if new operations added
Example

- Command X has parameters A, B
- A: A1, A2; B: B1, B2, B3
- A has much more effect on difference in code execution than B
- Two choices possible:
  1. All parameter values
  2. Most significant ones
     X:A1B, X:A2B
Some heuristics

- Ensure that the input space is reasonably covered
  - Identify input variables, include indirect input variables (states?)
- Rough guidance
  - for 0.99 reliability, cover 99% of the input space
- You can always post trim the set
Determine occurrence rates

- Draw from different information sources.
  - Existing field data.
    - Similar systems, earlier releases.
  - Existing business data.
  - Data collection (field operation monitoring, marketing surveys).
  - Simulate systems in order to determine event arrival rates for different operations.
  - Estimate, estimate, estimate…
## Example

<table>
<thead>
<tr>
<th>Operation</th>
<th>Occurrence rate (per hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phone no entry</td>
<td>10,000</td>
</tr>
<tr>
<td>Add subscriber</td>
<td>50</td>
</tr>
<tr>
<td>Delete subscriber</td>
<td>50</td>
</tr>
<tr>
<td>Process voice call, no pager, answer</td>
<td>18,000</td>
</tr>
<tr>
<td>Process voice call, no pager, no answer</td>
<td>17,000</td>
</tr>
<tr>
<td>Process voice call, pager, answer</td>
<td>17,000</td>
</tr>
<tr>
<td>Process voice call, pager, answer on page</td>
<td>12,000</td>
</tr>
<tr>
<td>Process voice call, pager, no answer on page</td>
<td>10,000</td>
</tr>
<tr>
<td>Process fax call</td>
<td>15,000</td>
</tr>
<tr>
<td>Audit section of a phone no database</td>
<td>900</td>
</tr>
<tr>
<td>Recover from hardware failure</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>100,000</td>
</tr>
</tbody>
</table>
Occurrence Rates

- If no accurate numbers available, use approximations and improve with time
- Utilize future users
- Sensitivity issues

<table>
<thead>
<tr>
<th>Dialing type attribute</th>
<th>Call destination attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard = 800</td>
<td>External = 560</td>
</tr>
<tr>
<td>Abbreviated = 200</td>
<td>Internal = 240</td>
</tr>
<tr>
<td>Total = 1000</td>
<td>External = 20</td>
</tr>
<tr>
<td></td>
<td>Internal = 180</td>
</tr>
</tbody>
</table>
Different users may have different usage patterns
- Average them out in a general operational profile
- System usage evolves over time
- Additional testing may be warranted
- Operations added/modified through upgrades

<table>
<thead>
<tr>
<th>Preoperation</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occ. Probability</td>
<td>0.54</td>
<td>0.36</td>
<td>0.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New operations</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td>Y</td>
<td>0.2</td>
<td>0.1</td>
<td></td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Invocation of an old operation may spawn activation of more than one new operation
Evolution of OP (cont.)

STEPS:
1. Approximate the new OP from the probabilities of old operations and their mapping to the new ones
2. Normalize the new probabilities

<table>
<thead>
<tr>
<th>Preoperation</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occ. Probability</td>
<td>0.54</td>
<td>0.36</td>
<td>0.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New operation</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Initial Occ. Probability</th>
<th>Final Occ Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>W</td>
<td>(0.54*1=) 0.54</td>
<td>(0.36*1=) 0.36</td>
<td></td>
<td>0.9</td>
<td>0.74</td>
</tr>
<tr>
<td>X</td>
<td></td>
<td>(0.36*0.2=) 0.072</td>
<td></td>
<td>0.072</td>
<td>0.059</td>
</tr>
<tr>
<td>Y</td>
<td>(0.54*0.2=) 0.108</td>
<td>(0.36*0.1=) 0.036</td>
<td></td>
<td>0.144</td>
<td>0.119</td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td></td>
<td>(0.1*1=) 0.1</td>
<td></td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>1.126</td>
<td>1</td>
</tr>
</tbody>
</table>
Operational Profile information can be utilized for:

1. Reviewing the functionality to be implemented (Reduced Operation Software).
2. Suggesting operations while looking for reuse opportunities (cost effective).
3. Plan a more competitive release strategy (operational development).
To cut schedules and cost:

- Allocate resources for requirements, design, code reviews among operations.
- Allocate systems engineering, architectural design, development and code resources among operations.
  - Allocation of test resources discussed later.
- Allocate development code and test resources among the modules.