Real World Problem at Cisco Systems

- Smart Call Home (SCH) is a component of Cisco Smart Services that offers proactive diagnostics and monitoring on network devices (routers, switches, etc.)

- The retrieval and extraction of intellectual capital (IC) from customer Service Requests is crucial to developing rules for SCH products
  - IC retrieval refers to basic keyword search for the purposes of locating relevant Service Requests
  - IC extraction refers to the more complex process of using the retrieved information for the development and management of SCH intellectual capital

- Currently the IC retrieval/extraction is time consuming and not easily scalable to new products

See paper (3)
The Service Request Portal (SRP) is a software product we have developed that allows Cisco engineers to rapidly identify and extract IC from customer Service Requests.

The SRP performs two major functions:

1. Reduces the number of Service Requests engineers have to read (Retrieval)
2. Reduces the amount of Service Request content engineers have to read (Extraction)

SRP was developed in collaboration with Danny Core (UCSC) and Sri Ramachandran (Cisco)

See paper (41)
SRP: User Interface

See paper (41)
SRP: Results

- The SRP significantly improved the engineer’s productivity when working with Service Requests
  - 60% improvement when retrieving IC
  - 30% improvement when extracting IC

- Initial user feedback:
  - “The portal looks just amazing. Our team will be using the portal for Syslogs IC creation”
  - “The tool helps to find the information easily when compared to C3 TOPIC search”
  - “It is useful to extract the information quickly”
Conceptual Design for Software Products

- Central to the success of the SRP was the use of a Conceptual Design “front-end” that was applied before designing and implementing the software product

- Conceptual Design process:
  1. Knowledge Capture (Product Intent)
  2. House of Quality
  3. Due Diligence (Reverse Engineering / Market Research)
  4. Function Structure
  5. Morphological Matrix
  6. Selection Criteria
  7. Utility Function

See paper (11)
Step 1: Knowledge Capture (Product Intent)

- In order to determine what the product would need to do we developed a model of the users’ current work process using interviews and focus groups.

- The model was then used to identify areas of the work process that would benefit from software automation.
  - Engineers have to manually examine the Service Request fields in order to determine if it is relevant.
  - The relevant parts of the Service Request must be manually within extracted from many pages.
  - Engineers must download Service Request attachments to their desktop before they could open them.

- It was determined that the overall intent of the product would be: “Facilitate searching for relevant Service Requests and extracting problem-solution pairs.”

Engineers Work Process:

1. Run a keyword search using service request database search engine to locate Service requests.
2. Locate relevant Service requests in the search results.
   a) Open the service request using the service request Viewer.
   b) Examine service request fields (technology, sub-technology).
   c) Locate and read the problem description.
   d) Locate and read resolution summary.
   e) Locate and read first and last correspondence.
3. Extract problem solution pairings from relevant Service requests.
   a) Re-examine the problem description, resolution summary, and first and last correspondence in more detail.
   b) Read case notes if necessary.
   c) Download and read attachments if necessary.
4. Use the problem-solution pairs to create smart network products.

See paper (12)
Step 2: House of Quality

- The House of Quality was used to identify the user needs for the SRP and relate them to the Technical Metrics for testing the SRP during software development.

- We focused on two types of user needs for the product:
  - **Usability needs**: characteristics that the product must embody, such as “easy to use”
  - **Functional needs**: functionality that the product will need to provide to the user, such as “be able to read Service Requests easier”

- The Technical Metrics were based on the engineers’ current work process.

<table>
<thead>
<tr>
<th>Primary Needs</th>
<th>Secondary Needs</th>
<th>Technical Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td></td>
<td></td>
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<tr>
<td>High performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locate relevant Service Requests</td>
<td>Be able to quickly assess relevance of SRs</td>
<td>8</td>
</tr>
<tr>
<td>Extract problem solution pairs</td>
<td>Be able to read SRs easier</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Be able to do broad searches</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Be able to do very targeted searches</td>
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</tr>
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<td>7</td>
</tr>
<tr>
<td></td>
<td>Seamlessly access to service request attachments</td>
<td>5</td>
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</tbody>
</table>

![Correlation Matrix Diagram](image)

Legend:
- Strong Correlation
- Medium Correlation
- Weak Correlation
- Positive Correlation
- Negative Correlation

See paper (19)
Step 3: Due Diligence (Reverse Engineering/Market Research)

- A due diligence survey was performed in order to ensure that we leveraged existing work inside and outside of Cisco:
  - Surveyed past and present projects inside Cisco to understand the landscape
  - Comprehensive research of commercially available tools
- We determined, based on the survey, that the desired product did not exist either inside Cisco or as a commercially available tool. Therefore we would develop a new software product (the SRP) to address the user needs

<table>
<thead>
<tr>
<th>Software Tools</th>
<th>Products (Vendor)</th>
<th>Summary</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Statistical Analysis | Enterprise Miner (SAS) | Tools for pattern and trend discovery in semi-structured data | Powerful and scalable | Expensive
|                  | Clementine (SPSS)  |          | Some of these tools such as SAS are already in use at Cisco | Difficult to use |
| Information Extraction/Retrieval | Lemur (Open Source) GATE (Open Source) | Tools for automatically extracting structured information from unstructured data | Access to source code allows these tools to be modified to SCH's needs | Lacking the documentation and user interface of commercial tools |
| Database Mining | Oracle Database Mining (Oracle) | Tools for trend and pattern discovery directly inside the database | Excellent performance/scalability | Requires database access |

Cisco Projects

<table>
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<tr>
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Step 4: Function Structure

- The Function Structure was used to determine the SRP function to connect the user needs with the functional specifications for the SRP.

- Each SRP function is related to a user need in the House of Quality:
  - The function “Locate relevant SRs” is derived from the primary user need “Locate relevant SRs”.
  - The “Search SR content” is related to the user need “Be able to do broad searches”.
  - “Search SR fields” and “search SR attachments” are related to the secondary user need “be able to do targeted searches”.

See paper (20)
### Step 5: Morphological Matrix

- The Morphological Matrix was used to capture feasible solution principles (realizations) for the SRP’s functional specification.

- We tried to capture a range of solution principles for each sub-function from simple to very complex. For example, consider the solution principles for the sub-function “remove repeated content”:
  - Low complexity: Strict hash based deduplication
  - Medium complexity: Fuzzy hash based deduplication
  - Very complex: Use a classifier to detect duplicate information

<table>
<thead>
<tr>
<th>Sub-Function</th>
<th>Solution Principle 1</th>
<th>Solution Principle 2</th>
<th>Solution Principle 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyword search SR content</td>
<td>Database access and cosine similarity based keyword search</td>
<td>Database access and regular expression keyword search</td>
<td>Leverage search engine results</td>
</tr>
<tr>
<td>Search SR fields</td>
<td>Augment search engine fields</td>
<td>Keyword search fields</td>
<td>Leverage search engine fields</td>
</tr>
<tr>
<td>Search SR attachments</td>
<td>Keyword and search by attachment type</td>
<td>Search by attachment type</td>
<td>Keyword search</td>
</tr>
<tr>
<td>Retrieve SR content</td>
<td>Database access</td>
<td>Search engine XML interface</td>
<td></td>
</tr>
<tr>
<td>Remove repeated content</td>
<td>Use a classifier to detect duplicate information</td>
<td>Fuzzy hash based deduplication</td>
<td>Strict hash based deduplication</td>
</tr>
<tr>
<td>Summarize SR contents</td>
<td>Natural language processing</td>
<td>Extract problem description and resolution summary, Remove stopwords and text noise</td>
<td>Extract problem description and resolution summary.</td>
</tr>
<tr>
<td>Access to attachments</td>
<td>Attachments displayed in user web browser with attachment type and keyword highlighting</td>
<td>Attachments displayed in user browser</td>
<td>User downloads attachments</td>
</tr>
<tr>
<td>Access to SR notes</td>
<td>Keyword highlighting with collapsible panes for each note type</td>
<td>Organized by note type</td>
<td>Plain text</td>
</tr>
</tbody>
</table>

See paper (22)
Step 6: Alternative Design Concepts

- Three different alternative design concepts for the SRP:
  1. “State of the Art” approach: use complex solution principles such as natural language processing
  2. “Hybrid” approach: combine existing Cisco software infrastructure with the new functionality desired by the users
  3. “Quick and Dirty” approach: use very simple solution principles such as regular expression matching
Step 7: Selection Criteria (Deriving the Utility Function)

- The Selection Criteria captured the development objectives for the SRP and allowed us to derive a Utility Function for evaluating design concepts with respect to these objectives.

- There were two overall development objectives for the SRP:
  - **Quality**: maximize the user value. This corresponded to the user needs specified in the House of Quality.
  - **Time**: minimize the development time for the SRP. This corresponded to the complexity of the solution principles (e.g. how long they would take to implement).
Step 8: Concept Selection Using the Utility Function

- The “Hybrid” design concept (3) was the highest utility design. It offered similar user value to the “State of Art” design concept (1) and was significantly less complex because a large part of the infrastructure was already in place.
Step 9: Software Engineering (Manufacturing)

- A typical Software Engineering process is consists of two distinct workflows:
  1. Software Design (Use Case Diagrams, Component Diagrams, Class Diagrams)
  2. Software Development (Planning, Coding, Testing)

- We followed conventional Software Engineering methods with the exception that we radically altered the drivers that feed into the design and development processes.

- Using the results of the Product Design phase ensured that the Software Engineering phase was sufficiently linked to the user needs for the product.
Software Engineering: Product Design Drivers

Use Case Diagram

Component Diagram

Class Diagram

Planning

Testing

See paper (31-40)
SRP: Implementation

- **Software Infrastructure**
  - Ruby on Rails/MySQL backend
  - HTML/Javascript user interface

- **Retrieval features**
  - Search for any combination of keywords or phrases within the body of the Service Request and text attachments
  - Include or exclude certain resolution codes
  - Search within any technology and sub-technology

- **Extraction features**
  - Grouping the bugs referenced in the Service Request summary and opening them from the portal
  - Opening text attachments from within the portal
  - Highlighting text around specified keywords in Service Request body in the summary
  - Present the first and last correspondence in Service Request summary
  - Highlighting text around specified keywords in Service Request attachment when opened
  - Tidy version gives nice color-coded logical flow of the Service Request and removes repetition
SRP: Results-1

- Average reduction of 85% (20+ to 3) in pages read per Service Request when establishing relevance

See paper (45)
- Average time savings of 60% (15 minutes) per Service Request when establishing relevance
SRP: Results-3

- Average time savings of 30% (30 minutes) per Service Request when extracting IC

See paper (46)
Conclusions

▪ Developing high quality software products at low cost requires:
  • Relating the user to the system
  • Thinking about the system functionally
  • Exploring different function realizations
  • Selecting the best “mix” of realizations based on the user needs and cost constraints

▪ Conventional Software Engineering does not provide structured methods for these activities

▪ Product Design methods and techniques can be used as a supplemental “front-end” to conventional Software Engineering methods in order to increase the quality and cost effectiveness of software products

See paper (46)