IBM Haifa Research Lab

Service Identification in Legacy Code Using Structured and Unstructured Analysis

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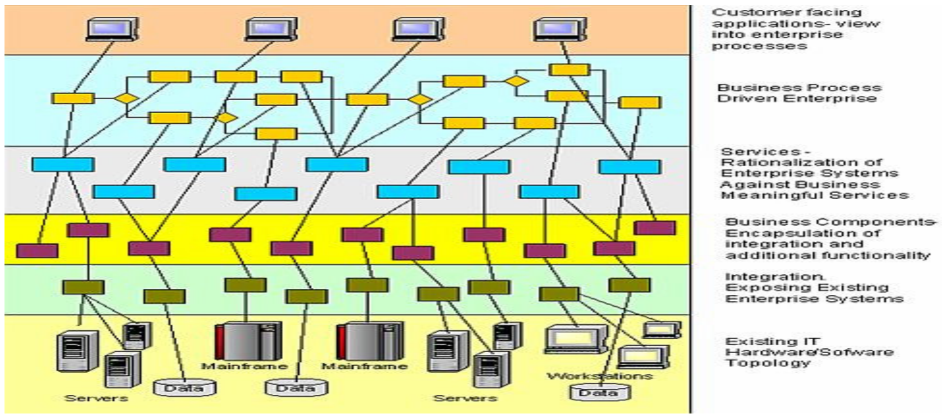
Outline

- **Motivation**
- **Structured and Unstructured Analysis**
- **Our Method**
- **Case Study**
- **Future Directions**
- **Conclusions**

SOA Transformation

- **Moving to SOA has become a strategic goal of many companies**
  - Flexible, distributed architecture
  - Better adaptation to a rapidly changing business environment
  - Better alignment of business processes and underlying applications with business goals

➡ **There is a need for tools that assist in the transformation process**


Customer facing applications- view into enterprise processes
Business Process Driven Enterprise
Services - Rationalization of Enterprise Systems Against Business Meaningful Services
Business Components- Encapsulation of integration and additional functionality
Integration. Exposing Existing Enterprise Systems
Existing IT Hardware/Sofware Topology
Mainframe
Mainframe
Servers
Data
Data
Servers
Workstations
Data

Reuse of Legacy Systems

- **Lots of resources and time have been spent on existing legacy systems**
- **Need to retain as much as possible of previous investments**
- **Requires identification of where a service or part of it is already implemented and can be reused**
- **Manual identification of candidate code sections is tedious and requires domain experts**

⇒ **A (semi) automatic tool is needed to assist in this process**

Transformation Approaches

- **Top Down**
  - Define *to-be* model and implement it
  - No consideration of existing system
- **Bottom Up**
  - Start from given legacy *as-is* system and expose as SOA
  - Harder to adapt to new business models
- **Meet in the middle**
  - Combine Top Down and Bottom Up approaches
  - Start from target to be model
  - Map into existing system
  - Exploit reuse and implement if needed

Structured and Unstructured Source Code Analysis

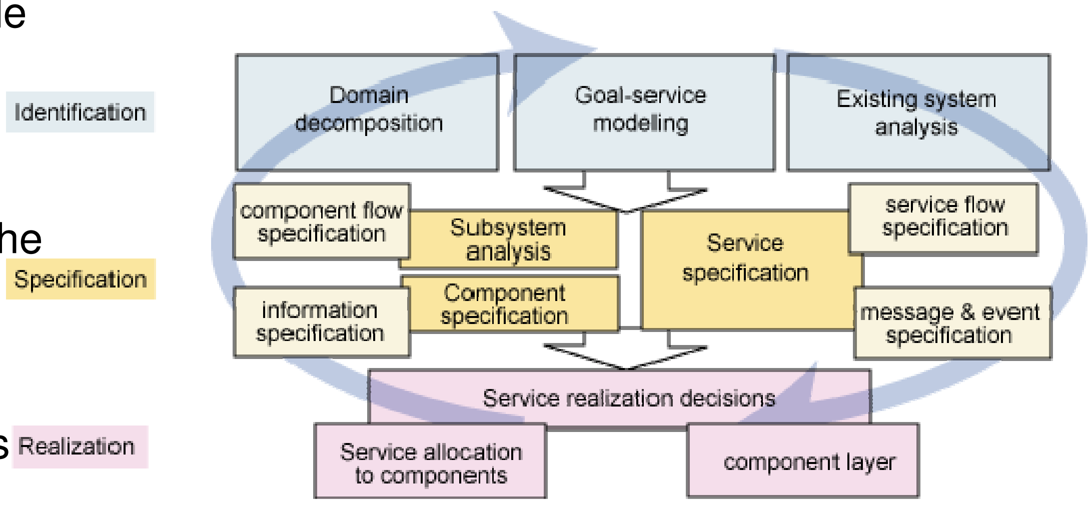
- **Unstructured Analysis**
  - Information Retrieval (IR) techniques, e.g. tokenization, usage of thesauri and stemming of source code and comments
  - No consideration of code structure and semantics
- **Structured Code Analysis**
  - Classic static analysis, e.g. control flow, data flow
  - No comment analysis
  - No identification of non-exact matches

⇨ **Combination of techniques facilitates effective and precise service implementation search**

SOMA – Service Oriented Modeling and Architecture

An IBM end-to-end SOA method for the identification, specification, realization and implementation of services, components and flows

- *Service Identification* – combines top-down, bottom-up, and meet-in-the-middle techniques for the identification of services to be implemented in the new SOA environment
- *Service Specification* – further designs the subsystems that were found in the previous step and specifies the coordination between them. Details the components that implement the services
- *Service Realization* - defines the software that realizes a given service



⇨Our method fits into the *Service Identification* phase

Service Identification Method

- **Service definition includes a *service title* – short functionality description (e.g. "Add a new customer account")**
- **Our method**
  - receives a service title as input
  - searches for potential implementations in the code
  - ranks the results by relevance to the service title

Example 1

find
“Add an account”

- **Identify `P0030-PROC-CREATE-ACCT` procedure**
  - The name indicates that it implements the desired functionality
  - Procedure name does not include the exact terminology
    - Contains `CREATE` - a synonym of “add”
    - Contains `ACCT` - an abbreviation of “account”.

```
000100 ID DIVISION.
000200
000300 PROGRAM-ID.   PROG1.
...
214000 PROCEDURE DIVISION
214100******************************
214400* HANDLES RECORD ADDITION
214410* REQUEST. AFTER OPERATION IS
214500* COMPLETED, EVENT REPORT IS
214510* CREATED. ACCOUNT MANDATORY
214600* FIELDS ARE SET IN THIS
214700* PROCEDURE
214800******************************
215000 P0030-PROC-CREATE-ACCT.
215100
215200   MOVE +0 TO TRAN-001-RECORD
```

Example 2

find
“Add an account”

- **Identify `P0040-PROC1` procedure**
  - The preceding comment resembles the desired service title
  - The comment adheres to the company convention:

    `PROC: <procedure description>`

⇨ **Match inside the convention strengthens the impression that the procedure is a good candidate**

```
000100 ID DIVISION.
000200
000300 PROGRAM-ID.   PROG2.
...
067000 DATA DIVISION.
...
075340 01 ACNT-NUMBER PIC S9
...
214000 PROCEDURE DIVISION
214050
214100*****************************
214200* PROC: ACCOUNT ADDITION.
214800*****************************
215000 P0040-PROC1.
215100
215150*** INITIALIZE NUMBER
215160*** BEFORE ADDING
215200   MOVE +0 TO ACNT-NUMBER
```

match inside procedure description

Example 3

find
“Add an account”

- **Identify `P0050-PROC-REP` procedure**
  - Neither procedure name nor its comment is relevant to the service title
  - References `AA-REQ-COUNTER` variable
  - The variable holds the “number of *add acct* requests” as stated by the variable definition comment

➡ **Low ranking**

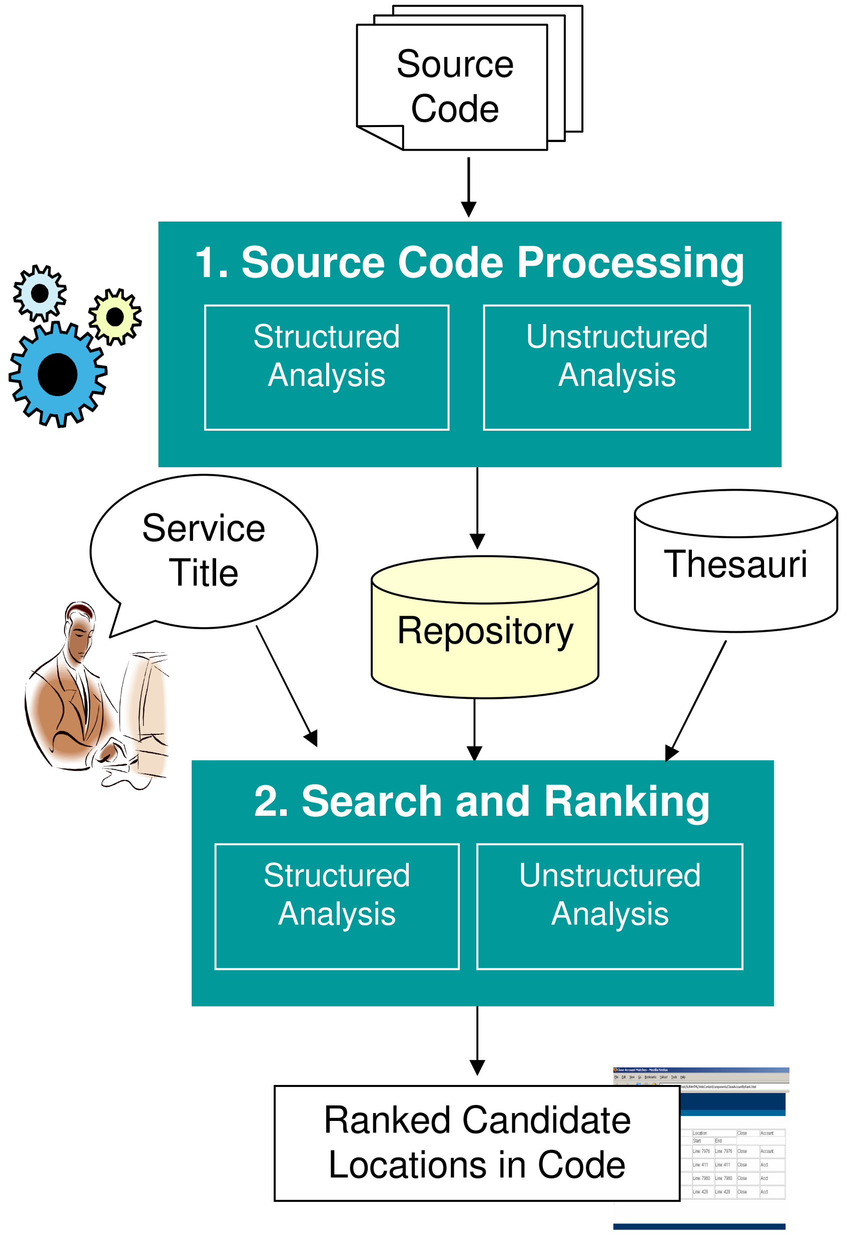
```
000100 ID DIVISION.
000300 PROGRAM-ID.   PROG3.
...
067000 DATA DIVISION.
...
075300** NUMBER OF ADD ACCT REQUESTS
075340 01 AA-REQ-COUNTER PIC S9
...
214000 PROCEDURE DIVISION
214100****************************
214150* PROC: PRODUCE REPORT
214160*
214200* PRODUCES VARIOUS KINDS OF
214300* REPORTS ABOUT REQUESTS THAT
214400* HAVE BEEN PROCESSED
214500*****************************
214600 P0050-PROC-REP.
214700
214800   MOVE +1 TO AA-REQ-COUNTER
```

variable
definition

Method Overview

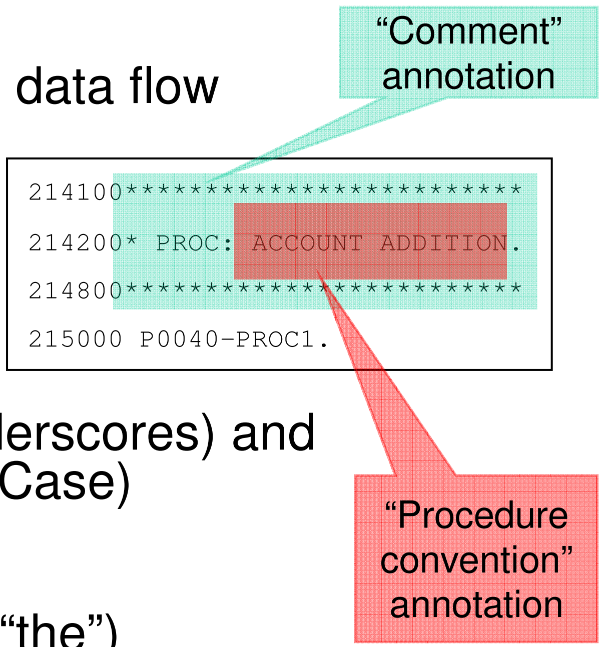
- **Stage 1: source code processing**
  - Analyze code structure
  - Identify components of interest in code and comments
  - Insert code and processing results into repository
- **Stage 2: search and ranking**
  - Search for service title matches in the artifacts that have been processed
  - Rank match relevance, taking into account structural and semantic context

* **Stage 2 can be repeated for multiple service titles over the same processed code artifacts**



Source Code Processing Stage

- **Identify programming constructs (e.g. variable declarations, procedure names, comments)**
  - Perform shallow analysis based mostly on a composition of regular expressions
  - Perform deep static code analysis (control flow and data flow detection)
  - Analyze comments, exploit conventions
  - Mark constructs using annotations
- **Tokenize - enable matching of substrings**
  - Consider special characters (spaces, commas, underscores) and code naming practices (Hungarian notation, CamelCase)
- **Insert tokens and annotations into repository**
  - Ignore tokens with low semantic value (e.g., “and”, “the”)
  - Our method uses a search engine as the repository (provides indexing and querying capabilities)



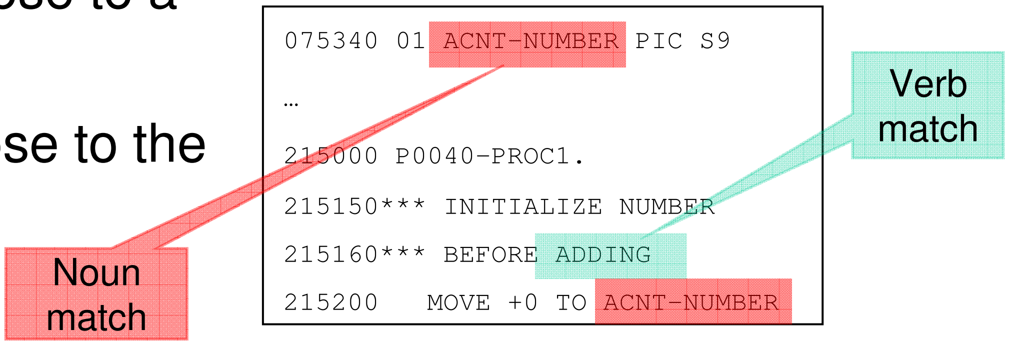
```
214100************************
214200* PROC: ACCOUNT ADDITION.
214800************************
215000 P0040-PROC1.
```

Search and Ranking Stage

- **Tokenize service title**
  - Apply the techniques used during the source code processing stage
- **Construct and execute search query**
  - Include the tokens from the service title
  - Exploit unstructured analysis capabilities of the search engine (e.g. stemming, thesauri and abbreviation usage) to search for inexact matches
    - Provide common language and domain-specific thesauri and abbreviation dictionaries to the search engine
- **Analyze query results**
  - Search engine returns the location of each query token occurrence (or its synonym)
  - The method assembles valuable occurrence combinations such that
    - There is exactly one match for every token (or one of its synonyms)
    - Token match locations are close to each other
- **Rank match relevancy**
  - Evaluate textual similarity: 100% for exact match of all service title tokens
  - Aggregate results to procedure level
  - Apply supplemental ranking heuristics based on semantic context

Ranking Heuristics

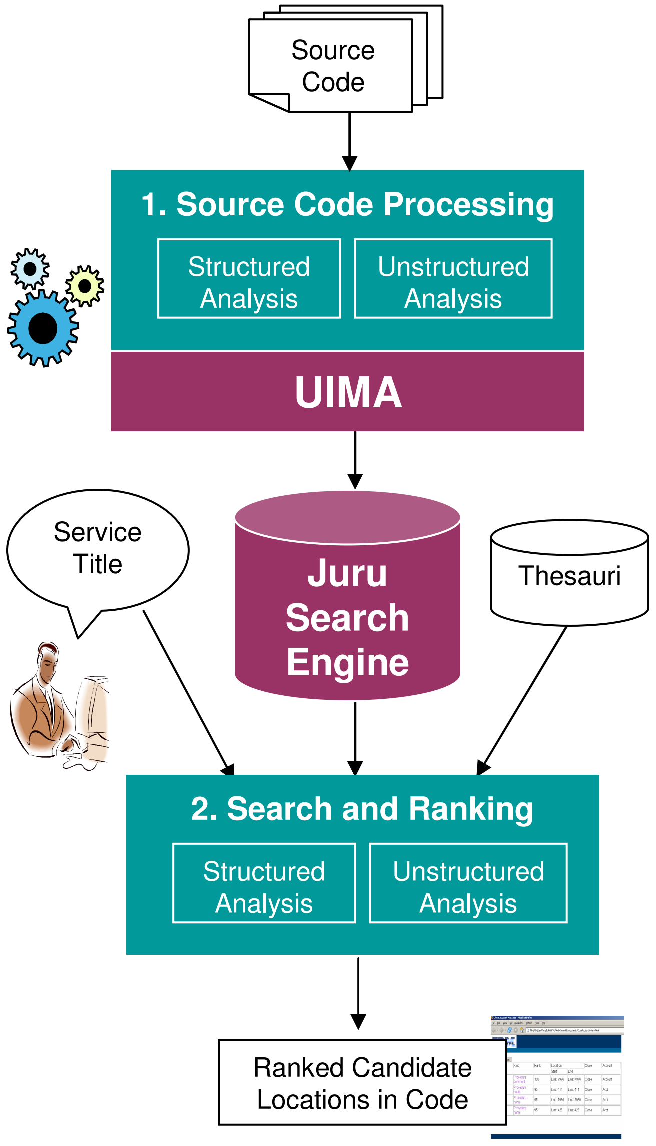
- **High score for match in procedure declaration**
- **Higher score for match in procedure declaration and in the adjacent comment**
- **Match in variable declaration or close to it**
  - Use data flow analysis results to find variable referencing code
  - Identify the reference location as a match with low score
  - The rationale: variable definition comment might include the service title, no additional comment in the variable usage code
- **Separate matches for service title subject (noun) and action (verb)**
  - Look for noun matches in or close to a variable declaration
  - Look for verb matches in or close to the variable referencing code



```
075340 01 ACNT-NUMBER PIC S9
…
215000 P0040-PROC1.
215150*** INITIALIZE NUMBER
215160*** BEFORE ADDING
215200    MOVE +0 TO ACNT-NUMBER
```

Case Study Implementation

- **Implemented a plug-in to an internal IBM tool that supports the IBM SOMA methodology**
- **Leveraged the Unstructured Information Management Architecture Open Source framework (UIMA)**
- **Used Juru as the underlying search engine**
- **Enables the user to select a service definition from the to-be model**
- **Returns a list of ranked implementation candidates**



Case Study

- **Used a customer application (a large bank in North America)**
  - Consists of a set of 30 COBOL programs and 48 copybooks, with a total size of 60K lines
- **Searched for six service titles that are common for banking applications**
- **Search in two levels**
  - The program level – identify the program that is more likely to contain the requested functionality, by calculating the total match rate in proportion to its size
  - The procedure level – search for specific procedures that implement the requested functionality. The rank given to each procedure was calculated using the heuristics described before

Case Study Results

- **Manual inspection of the procedures pointed to by our method shows that the results are valuable with 80% success rate**
  - Users are provided with valuable candidates in the legacy code for service realization
  - Greatly assists in the transition to a SOA enabled architecture
- **For service title “Reject Transaction” the results were inconsistent**
  - The service title is too general and not sufficiently focused
    - A transaction is a widely used concept in COBOL programs
    - The rejection operation can appear everywhere a transaction occurs

Case Study Results cont.

- **Some programs appear in the result list of the program level search only**
  - A match rate that depends only on the textual fitness of the searched service title to the code text is not accurate enough
  - The additional heuristics focus the results on more appropriate areas in the code
- **Identified a main program (A) that routes the execution to different programs according to the business function**
  - Guides the user to the entry point of most of the business functions, from there the execution path of a specific function can be followed

Service Title	Program ranked first	Program ranked second	Program ranked third
Terminate Payment	D	B	A
Reject Transaction	I	J	C
Modify Status	F	A	B
Modify Rating	G	H	-
Close Account	F	A	H
Open Account	B	F	M

Service Title	Procedure ranked first	Procedure ranked second	Procedure ranked third	Procedure ranked forth	Procedure ranked fifth
Terminate Payment	A1	A2	A3	G1	D1
Reject Transaction	A4	H1	A5	A6	A7
Modify Status	F1	A8	A9	F2	A10
Modify Rating	G2	G3	G4	G5	G6
Close Account	A11	A12	A13	A14	F3
Open Account	A15	B1	A3	F4	A16

Future Directions

- **Use additional Natural Language processing (NLP) techniques**
  - Consider sentence breaks in comments, e.g. "… account. Open…"
  - Identify main noun and verb in service title, e.g. for title "Open a new user account" identify "account" and "open"
    - Give higher ranking to these in query and ranking
    - In OO code look for class names that include the noun and method names that include the verb
    - Identify matches that include a verb in procedure declaration and a noun as one of the parameter names or variable names in the body
  - Consider whether a token in title is a verb or noun during query expansion, e.g. for "Record Status", "record" is a verb and not a noun

Future Directions cont.

- **CRUDL (Create, Read, Update, Delete or List) Analysis**
  - Identify language constructs that perform these tasks, e.g. for the notion of “creation” in the service title look for `INSERT` in SQL or `new` and `malloc` statements in code
- **Consider additional information on a service in the model, e.g.**
  - Service descriptions
  - Service interfaces
- **Consider feedback from previously performed mappings**

Summary

- **Presented a method for the identification of services in legacy source code in the context of SOA transformation**
- **The technology uses a combination of structured and unstructured analysis techniques over source code and its comments**
  - Considers information found in comments
  - Elaborates in-exact matches
  - Takes into account structural and semantic context of a match during ranking
- **Compared to manual inspection of the code, which is the prevalent practice nowadays, our method significantly reduces the required effort**

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