
Applying Case-Based Reasoning to Spatial-temporal Analysis of Residential Burglary Crime Investigation: A Cloud Service Prototype

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- Solving Problems using Case Based Reasoning
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- Case Studies Results and Discussions
- Conclusions and Future Studies

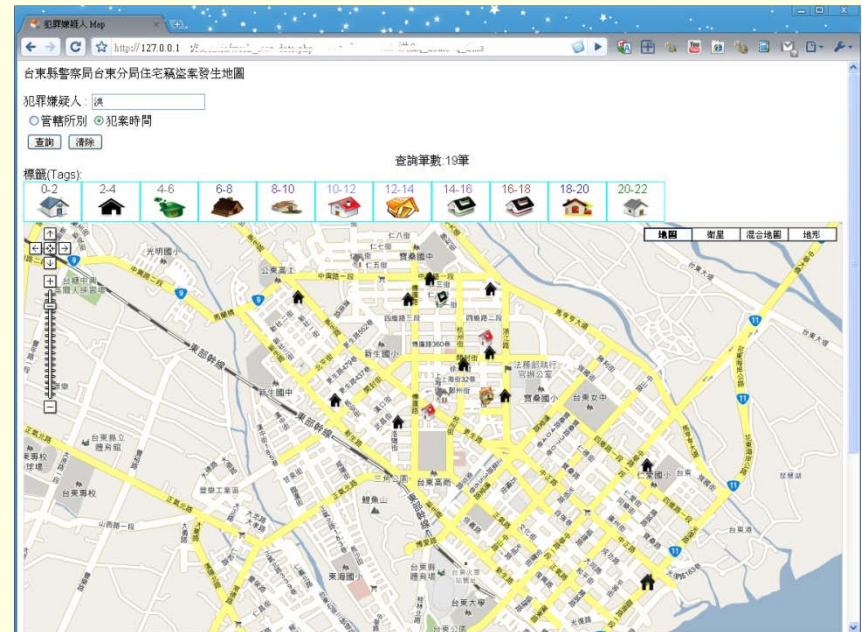
Abstract

- A lot of researches have been done by applying the features of modus operandi, the influence factors of victims, crime prevention measures, and geographic profile of consecutive crime for the investigation of the residential burglary crime.
- The main objective of this research is to develop a decision support system by applying case-based reasoning (CBR) method for residential burglary investigation using the spatial and temporal evidences of crime case.
- A cloud service prototype is proposed for developing future collaboration mechanism between organizations.

The Spatial and Temporal Evidences of Burglary Crime and CSI



Spatial Distribution of Burglary Cases



Temporal Distribution of Burglary Cases



Habitual Thieves: Re-appear in certain Places, Periods, Time, and Pattern

Modus Operandi: Skill, Preference, Habits

Criminal Profiling: Evidences from Personality, Features, Field Response

The Limitations of Rules in CSI

- The success of rule-based expert systems is due to several factors:
 - They can mimic some human problem-solving strategies
 - Rules are a part of everyday life, so people can relate to them
- However, a significant limitation is the *knowledge elicitation bottleneck*
 - Experts may be unable to articulate their expertise
 - Heuristic knowledge is particularly difficult
 - Experts may be too busy...

Another Way of CSI from Past Experiences

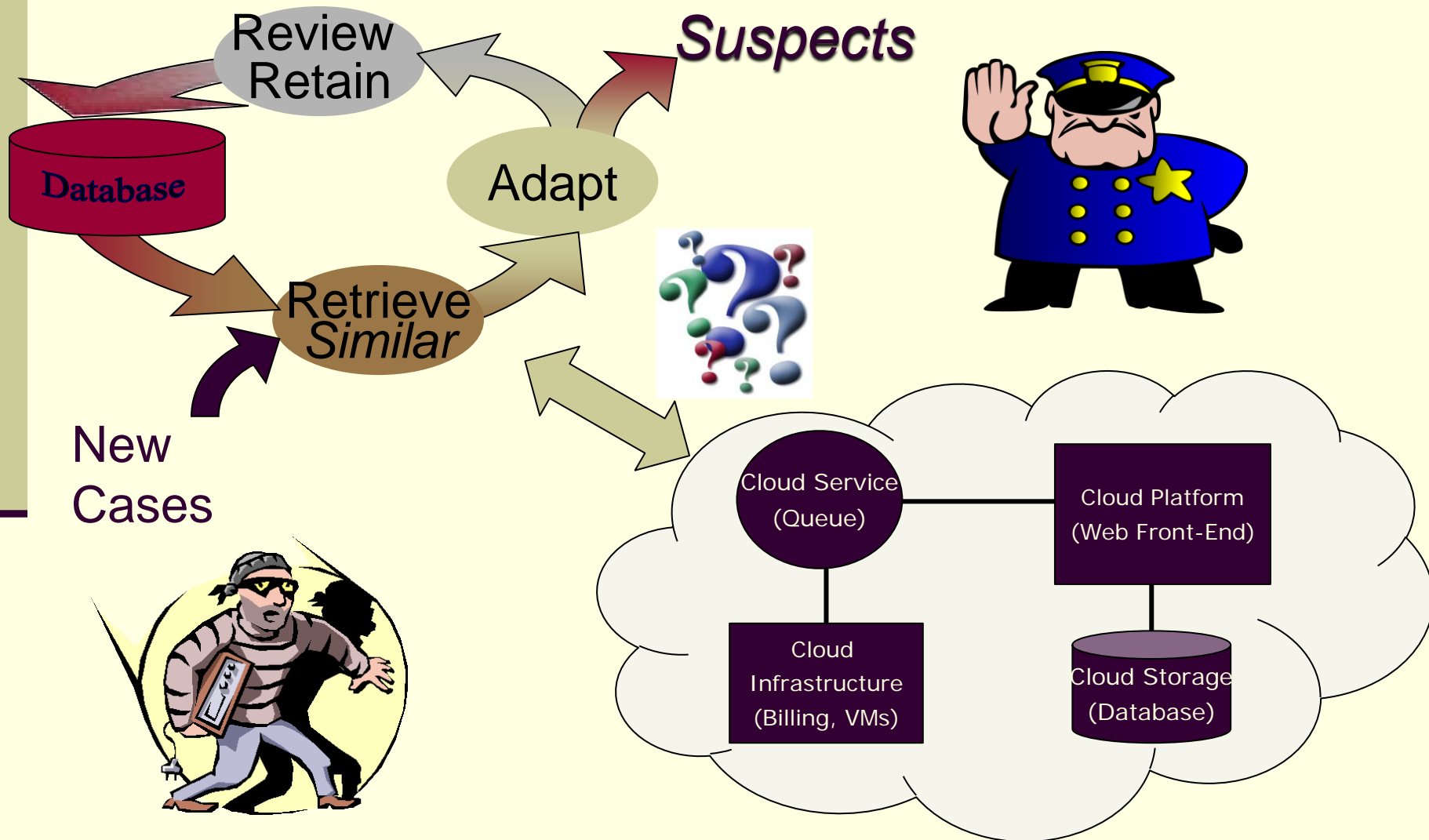
- By referring how we solved similar burglary cases in the past.
- This is Case Based Reasoning (CBR)
 - *memory-based* problem-solving
 - *re-using* past experiences
- Experts often find it easier to relate stories about past cases than to formulate rules
- The main assumption is that:

Similar burglary cases have similar patterns and evidences

R⁴ Cycle

- **Retrieve** the cases from the case-base whose problem is most similar to the new case.
- **Reuse** the solutions from the retrieved cases to find the suspects for the new case.
- **Revise** the proposed suspect to take account of the evidences between the new case and the evidences in the retrieved cases.
- **Retain** the new case and its revised suspect as a new case for the case-base if appropriate.

The CBR Cycle and Computation/Service Needs

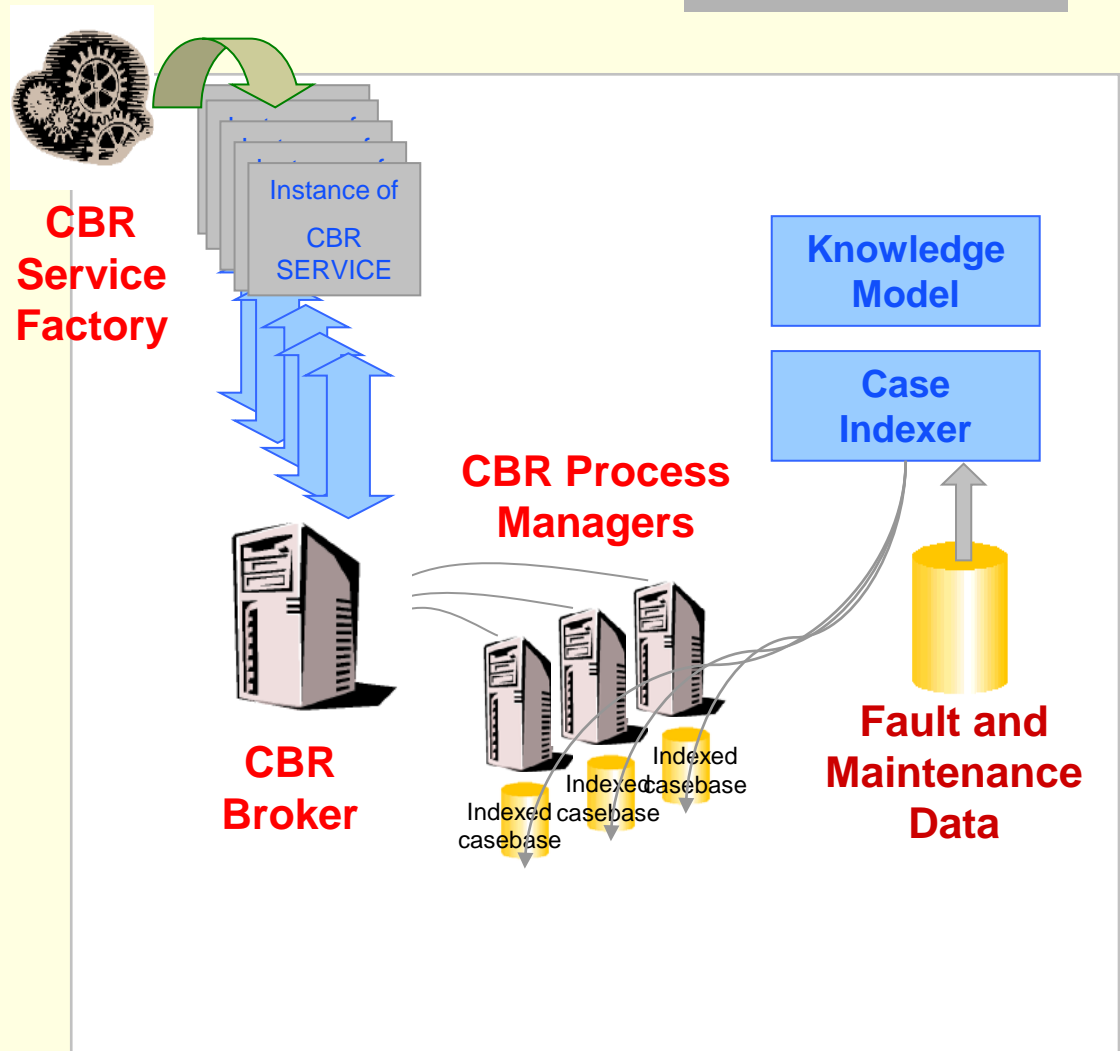


Concepts of Case Base Reasoning and Cloud Service

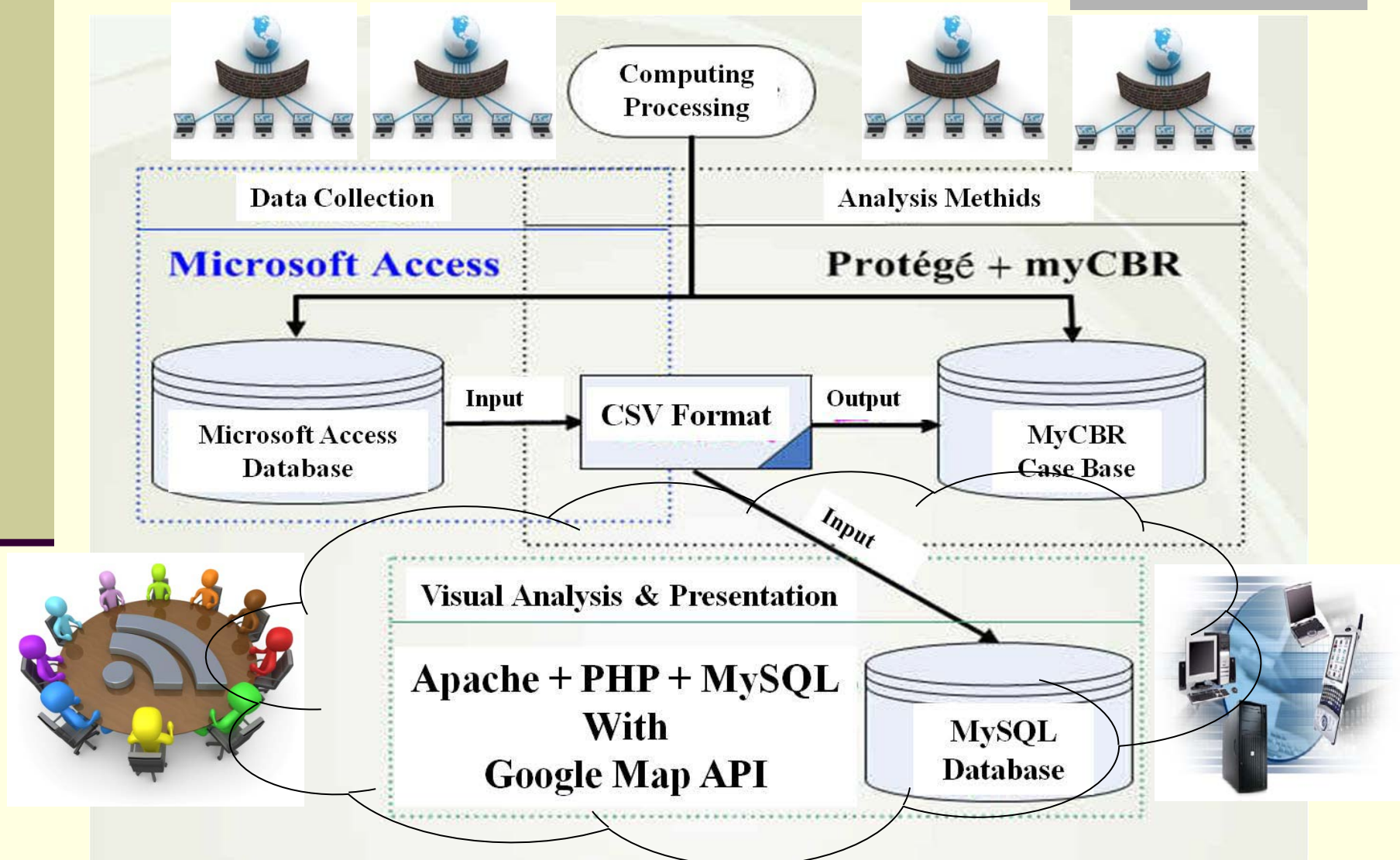
CBR service is provided via **Cloud service** interface to a commercial CBR package

A *Service Factory* supports the creation of multiple CBR instances

- Permits many CBR processes to be executed in parallel from a single service access point



The Conceptual Diagram for Cloud Service Prototype



Similarity Value Measurement

$$\text{Similarity}\left(f^I, f_j^R\right) = \frac{\sum_{i=1}^n w_i \times \text{sim}\left(f_i^I, f_{ji}^R\right)}{\sum_{i=1}^n w_i}$$

$\text{Similarity}\left(f^I, f_j^R\right)$: Similarity Value with the j th case in case base

f^I : New Case

f_j^R : data of the j th case in the case base

n : number of feature indicator f_i^I : the i th feature value of new case

i : total number of features

f_{ji}^R : the i th feature value the j th

w_i : the weight of i the feature

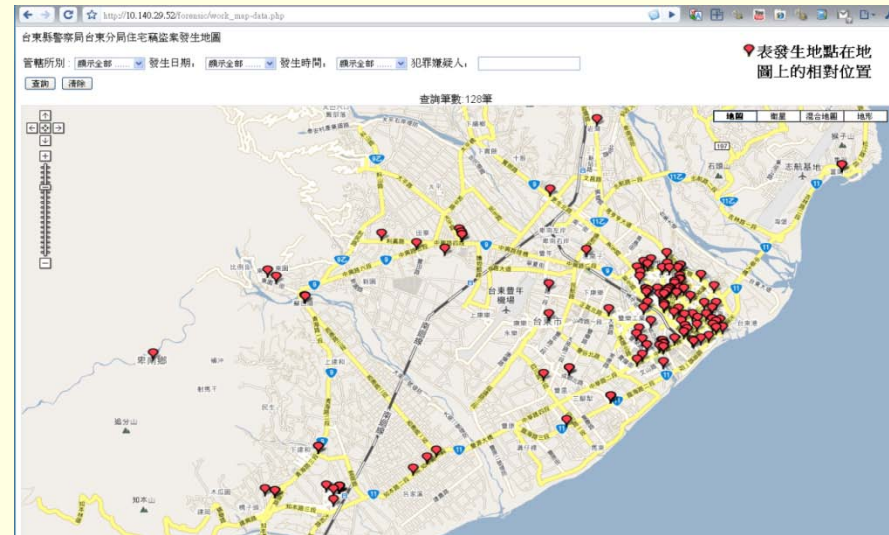
case in the case base

$\text{sim}\left(f_i^I, f_{ji}^R\right)$: the similarity value of the new case and the i th feature of the j th case in the case base

Case Studies Results and Discussions

id	casename	address	lat	lng	flag	crimedate	crimeweek	crimetime	crimetype	suspect	caseno
31	台東市寧波路		22.762	121.147	960708	週日	4-6	中興所	謝C	31	
32	台東市中正路		22.752	121.159	960730	週一	0-2	寶鼎所	林A	32	
33	台東市寶高路		22.752	121.158	960801	週三	0-2	寶鼎所	林A	33	
34	台東市新莊路		22.752	121.149	960822	週三	8-10	中興所	張D	34	
35	台東市博愛路		22.752	121.150	960822	週三	14-16	寶鼎所	郭A	35	
36	台東市延州路		22.777	121.123	960825	週末	8-10	永樂所	江A	36	
37	台東市杭州路		22.762	121.146	960901	週末	18-20	中興所	林E	37	
38	台東市成城路		22.732	121.129	960903	週一	6-8	中興所	張D	38	
39	台東市渠中街		22.754	121.138	960906	週四	10-12	馬場所	郭A	39	
40	台東縣卑南鄉溫泉路		22.696	121.023	960906	週四	10-12	溫泉所	王D	40	
41	台東市中山路		22.752	121.148	960908	週末	18-20	中興所	李C	41	
42	台東市中華路一段		22.747	121.143	960909	週日	20-22	中興所	李C	42	
43	台東縣卑南鄉東成路		22.836	121.081	960916	週日	10-12	初鹿所	郭A	43	
44	台東市博愛路		22.752	121.143	960924	週一	12-14	中興所	李C	44	
45	台東市中華路五段		22.772	121.079	960924	週一	12-14	利菁所	郭A	45	
46	台東市中華路二段		22.744	121.138	960928	週五	22-24	豐里所	李C	46	
47	台東市中華路四段		22.777	121.086	960929	週末	12-14	利菁所	吉A	47	
48	台東市濱南路		22.762	121.139	960929	週末	2-4	馬場所	孫A	48	
49	台東市興地路		22.804	121.126	961006	週末	16-18	南王所	陳A	49	

The 128 collected burglary cases in DB



The spatial distribution of collected Burglary Cases

- **128** burglary crime case between **2007-2009** have been collected from the jurisdiction of **2** local police stations.
- **3 Categories**(Spatial and Temporal, Convict Approaches, Field Characteristics) with **11 features** and **82 factors** are used for CBR.



Burglary Crime Case Processing

欄位名稱	資料類型	描述
case_no	自動編號	
Happen_date	日期/時間	發生日期
Happen_time	文字	發生時間(1.0-2時 2.2-4時 3.4-6時 4.6-8時 5.8-10時 6.10-12時)
Happen_place	文字	發生地點
Happen_area		
Residential_patterns		
In_method		
Crime_tool		
Stolen_goods		
In_point		
out_point		
In_behavior		
Evidence		
Suspect_name		
Suspect_date		
Suspect_place		

Step 1

Data in Access Table format

Step 2

Import to Access DB

Step 3

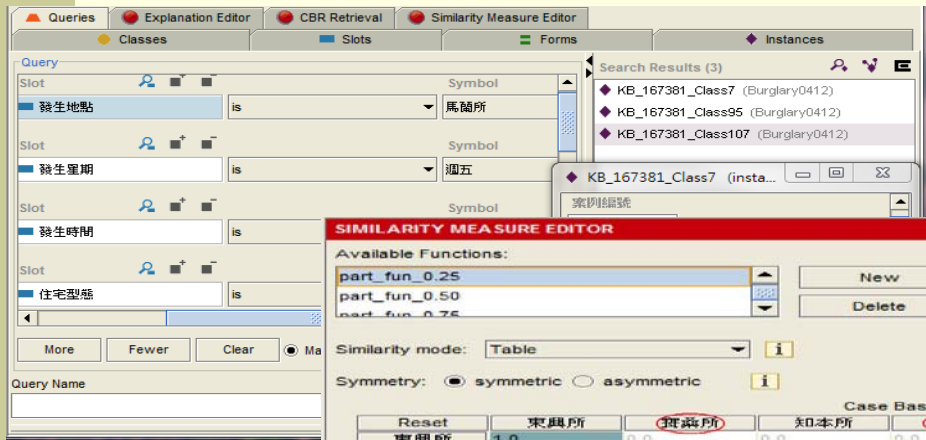
Import to myCBR

Step 4

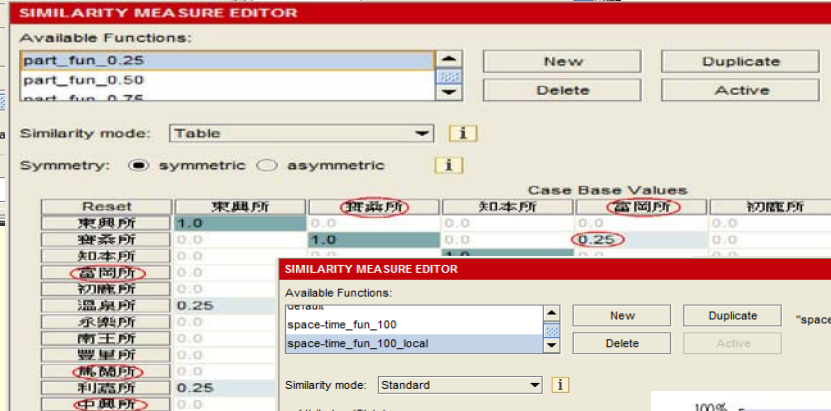
Finished in myCBR for further use

The screenshots illustrate the workflow from data import to case editing in the myCBR system. The 'Importer' window shows a CSV file with columns like 'case_no', 'Happen_date', 'Happen_time', 'Happen_place', 'Happen_area', 'Residential_p...', 'In_method', and 'Crin...'. The 'CLASS BROWSER' shows a hierarchy where 'Burglary0412' is the main class. The 'INSTANCE BROWSER' lists instances such as 'KB_167381_Class1' through 'KB_167381_Class106'. The 'INSTANCE EDITOR' provides a detailed view of an instance, with fields for '案別編號' (101), '發生時間' (12-14), '發生星期' (週五), '發生地點' (萬國所), '住宅型態' (連棟式), '侵入方法' (暴力侵入), '犯罪工具' (破壞剪), '被竊物品' (其他), '侵入處' (防火安全梯), '證據處' (防火安全梯), '搜尋罪行' (翻箱倒櫃), and '現場證據' (鞋印).

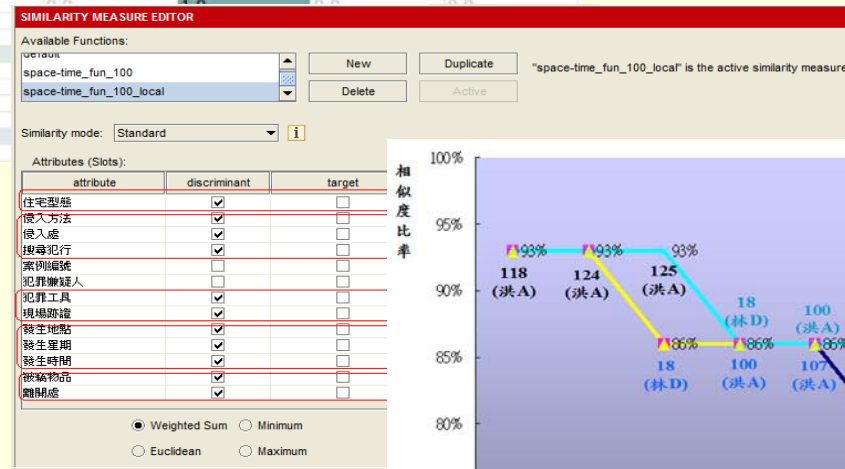
Burglary Crime Case Analysis



Step 1
New case input to myCBR

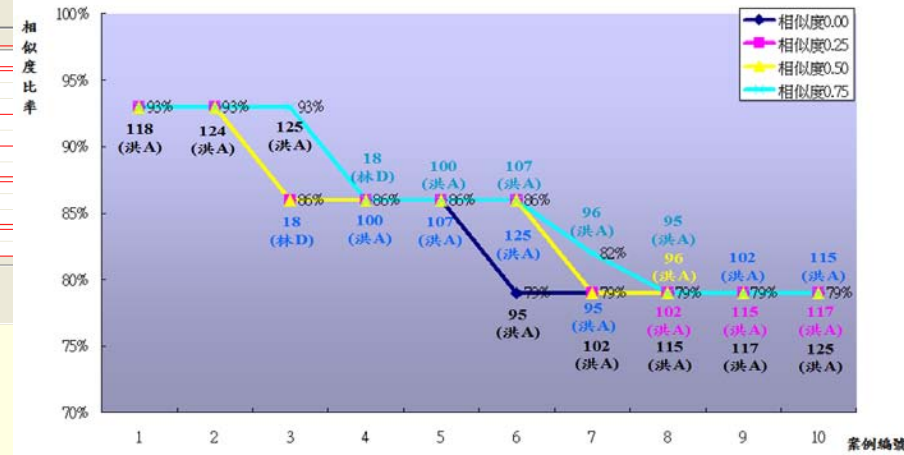


Step 2
Calculate Similarity Value

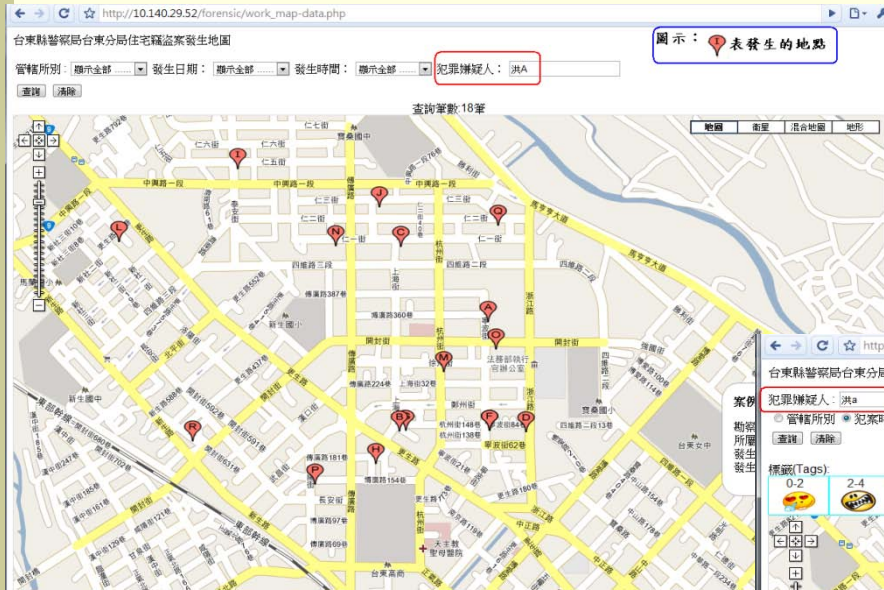


Step 3
Similarity Matrix

Step 4
Graphic comparison analysis

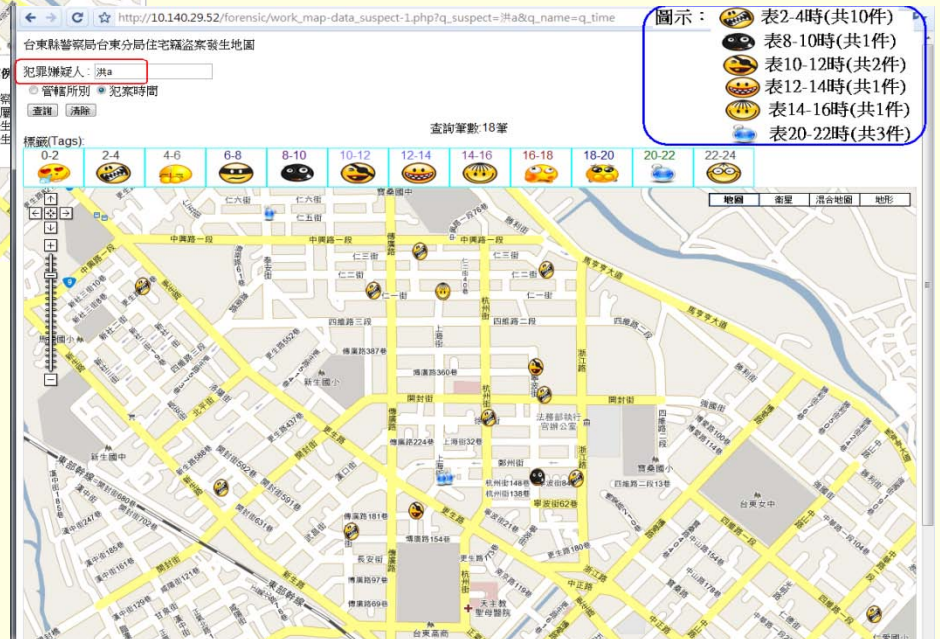


Burglary Crime Case Spatial and Temporal Analysis



Spatial location visual display and analysis on certain suspect derived from case base.

Temporal correlation visual display and analysis on certain suspect derived from case base.



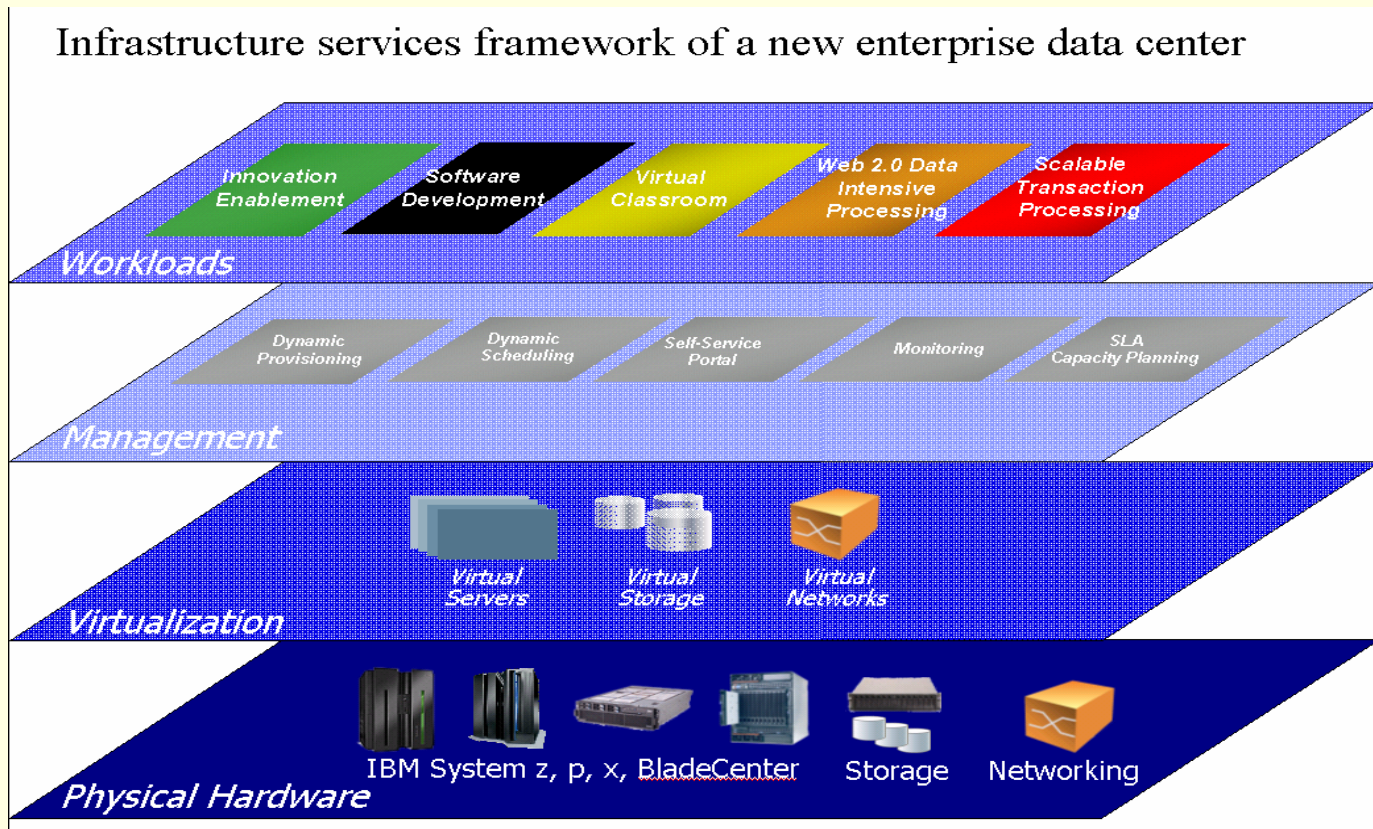
All these analysis results will be shared in Intranet using cloud service

Conclusions

- The considered methods and mechanism have been used to develop the cloud service prototype.
- Case studies show the reliability and validity of the prototype.
- The spatial and temporal analysis results sharing mechanism developed by using Google map API can improve the efficiency of burglary cases CSI among related agencies.
- Serious computation power and cloud service security mechanism are needed to be considered before further implementing the prototype to provide online service.

Future Studies

Comprehensive mechanism and technologies of Cloud Service are needed for further development.



Thank you for your attention



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