



Capture and Validation of Multi-Lingual Requirements Using Essential Use Cases

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What is Multi-lingual Requirements?

- Requirements express in >than 1 languages
- Used in countries where English is not the native language and may occur in outsourcing situations for Global Software Development.
- Example: Malaysia → English and Malay languages , **“Code-switching”**
- Leads to inconsistency and misinterpretation



Motivations

- Limited work to capture and validate multi-lingual requirements
- Limited tool to capture and validate the consistency of multi-lingual requirements
 - especially for Malay and English language requirements

Motivations: Real Example

Sales Request Inquiry

Upon creation of booking, DMS system will validate if any booking falls under Special Sales Programme and generate unique sales request number for each transaction. Sales request will carry a "New" status. Meanwhile, booking function will introduces a new status "In Process" as to indicate that this sale belongs to Special Sales (MM2H, PAKAR, Embassy, Government), Parliament or Tourism. Any new sales request gives the user an option to either submit or cancel the sales request from this Sales Request Inquiry page.

As part of the requirements in the Special Sales Programme, user must attach the required document prior to the submission of a sales request. Document attached may be deleted according to necessity. At this stage, any cancellation to the sales request requires the user to recreate a new booking. Otherwise, the request will be submitted to HQ for approval. A successful submission will carry a "Submitted" status.

User Intention	System Responsibility
	1.validate booking
	2.generate id
	3.provide status
	4.offer choice
5.attach document	
	6.ask user
7.create booking	

Pemohonan Pertanyaan Jualan

Semasa pengwujudan tempahan, sistem DMS akan menyemak tempahan sekiranya terdiri daripada Program Jualan Istimewa dan mengeluarkan nombor unik permohonan jualan pada setiap transaksi. Pemohonan jualan akan membawa kepada status "Baru". Sementara fungsi tempahan akan diperkenalkan ke status "Dalam Proses" untuk mengenalpasti bahawa jualan tersebut adalah hak milik Jualan Istimewa (MM@H,PAKAR,Kedutaan,Kerajaan), Parlimen atau perlancongan. Sebarang permintaan baru jualan memberi pilihan kepada pengguna samada menghantar atau membatalkan permohonan jualan dari laman permohonan Jualan.

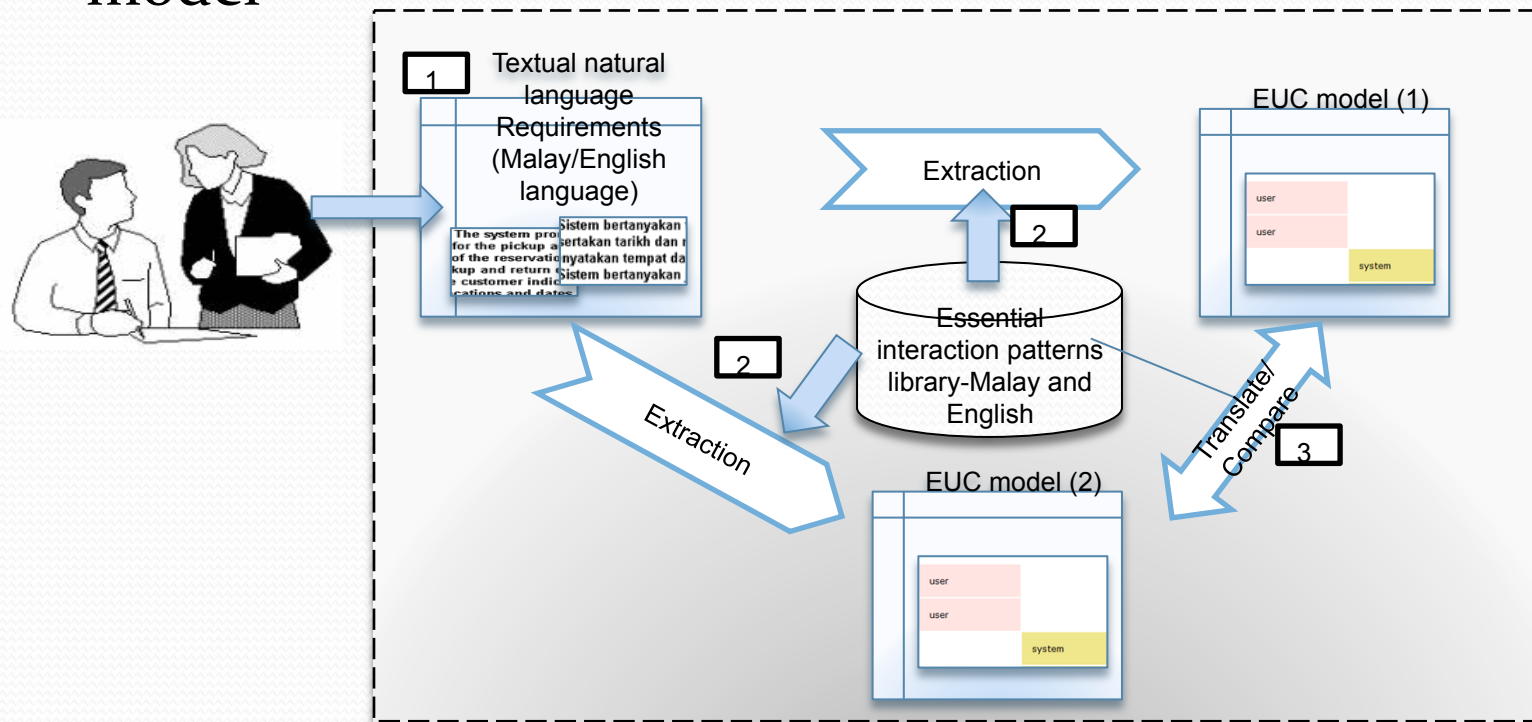
Pengguna perlu mengepilkan dokumen yang dikehendaki semasa pengantran permohonan jualan sebagai salah satu keperluan dalam Program jualan Istimewa. Pada fasa ini, sebarang pembatalan kepada jualan memerlukan pengguna membuat tempahan baru. Sekiranya tidak, permohonan akan dihantar ke HQ untuk penerimaan. Pemohonan yang diterima akan membawa status "hantar".

User Intention	System Responsibility
	1.semak tempahan (<i>validate booking</i>)
	2.mengeluarkan id (<i>generate id</i>)
	3.memben status (<i>provide status</i>)
	4.memben pilihan/ <i>offer choice</i>)
5.kepil dokumen (attach document)	
6.membuat tempahan (<i>make reservation</i>)	
7.(missing)	

Example of detected inconsistencies and errors

Our Approach

- Developed a new approach, MEReq (Malay-English Requirements)
- Uses Essential Use Cases (EUCs) as a semi-formalised model



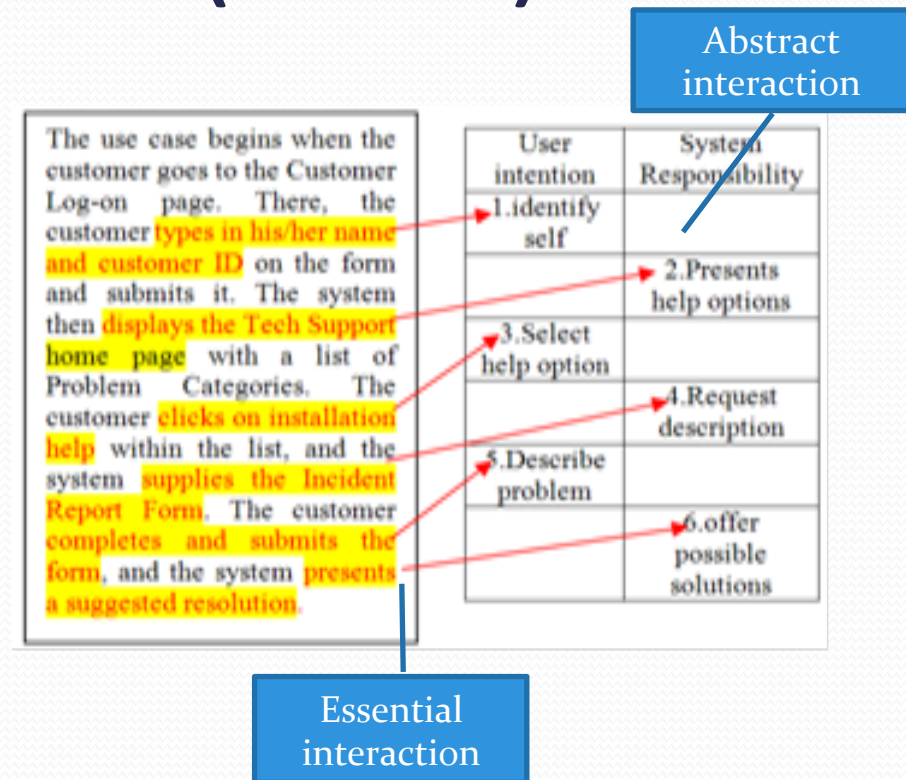
Inconsistencies Detection

- *Different naming of abstract interactions* - abstract interactions in both EUC models should have the same name or same meaning;
- *Different sequence of abstract interactions* - the same, or an appropriate equivalent, sequencing of abstract interactions should occur in both EUCs. Abstract interactions should be consistent with sequence ordering of their essential interactions in the textual NL requirements.
- *Different essential interactions* - essential interactions in English requirements need to be consistent with essential interactions in Malay requirements, but taking into consideration differing linguistic and cultural uses of language used to express the requirements in each.

Essential Use Cases (EUCs)

“structured narrative, expressed in a language of the application domain and of users, comprising a simplified, generalized, abstract, technology free and independent description of one task or interaction that is complete, meaningful, and well-defined from the point of view of users in some role or roles in relation to a system and that embodies the purpose or intentions underlying the interaction”

(Constantine and Lockwood,2001).



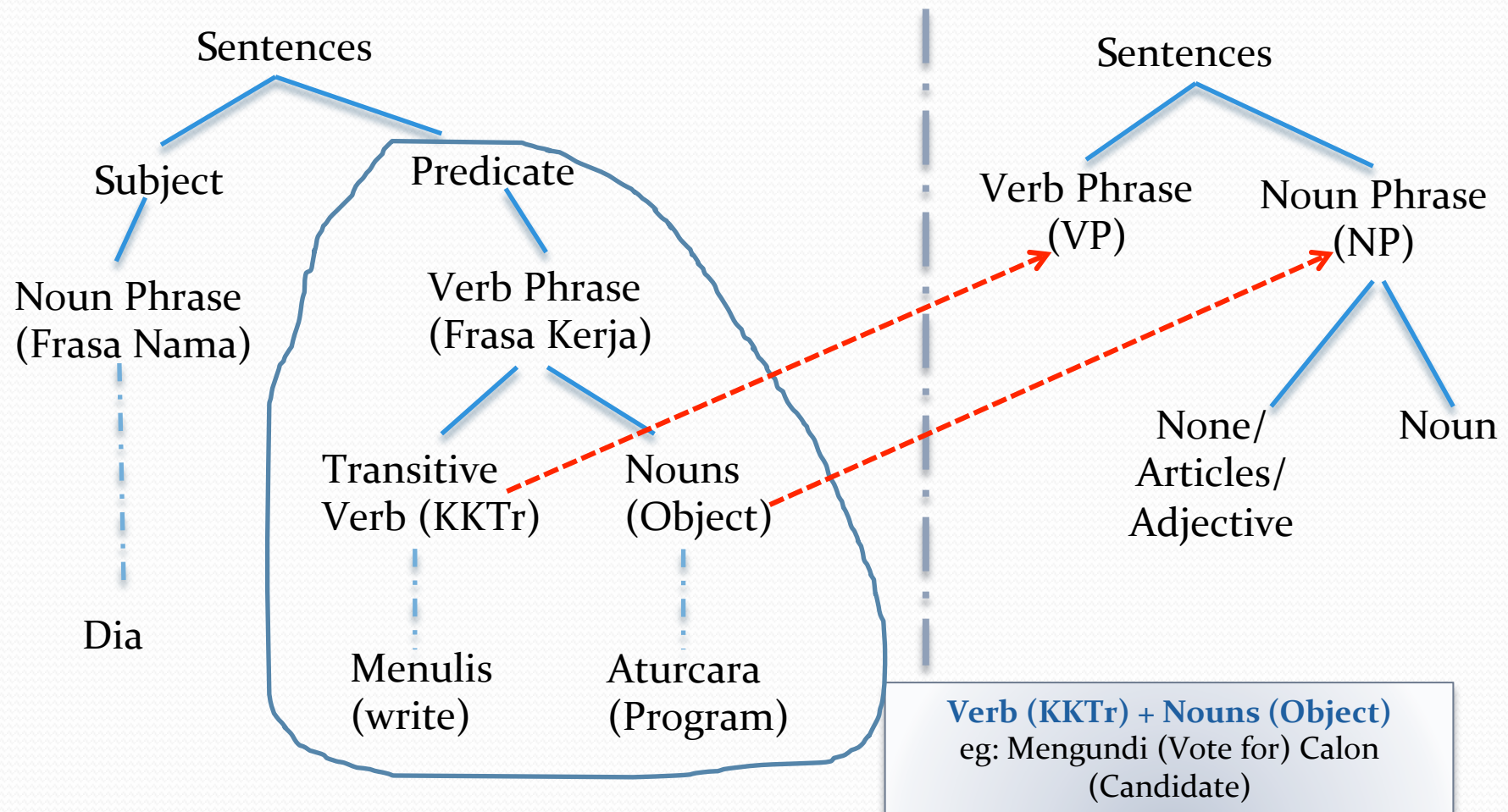
Example of generated EUC model (right) from the textual natural language requirements (left) adapted from (Constantine and Lockwood,2001)



Essential Interaction Patterns

- Based on a collection of phrases (**essential interaction**) that illustrate the function or behaviour of a system and a collection of essential requirements called **abstract interaction**.
- Abstract interaction pattern is associated with more than one essential interaction for various domains of application.

Key-textual Structures



Example of Essential Interactions Pattern library

Abstract interaction	Essential Interaction
Simpan data (save data)	Menyimpan rekod (save the record)
	Menyimpan maklumat (save the information)
	Menyimpan data (save data)
Semak status (check status)	Menyemak status permohonan (check an application status)
	Menyemak status tempahan (check booking status)
	Menyemak maklumat terkini (check current information)
Daftar ahli (register member)	Mendaftarkan kad pengenalan (register an identity card)
	Mendaftar nombor id (register an id number)
	Mendaftarkan nama (register name)

MEReq Tool Support

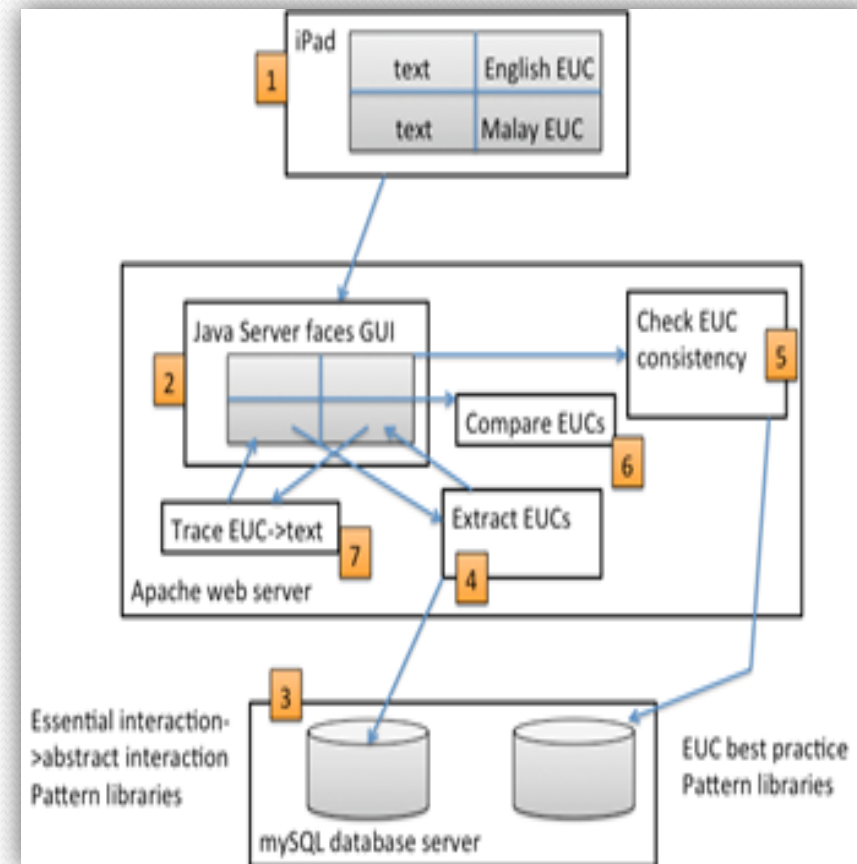
- Refinement of our previous tool, MaramaAIC (Automated Inconsistency Checker)^{1,2}, using a more accessible platform of web-based and mobile-based interfaces, designed for use on an iPad.
- Helps to lessen costs (time and effort) of manual translation, consistency checking and validation.

¹ M.Kamalrudin, J.Grundy, J.Hosking, "Supporting Requirements Modelling in the Malay Language using Essential Use Cases", in *Proc. IEEE Symposium on Visual Languages and Human-Centric Computing, IEEE, 2012. Innsbruck, Austria*

² M. Kamalrudin, J.Grundy, J.Hosking, "MaramaAI: Tool Support for Capturing and Managing Consistency of Multi-lingual Requirements", in *Proc. 27th Automated Software Engineering 2012 (ASE 2012), ACM: Essen, Germany.*

MEReq Tool Support

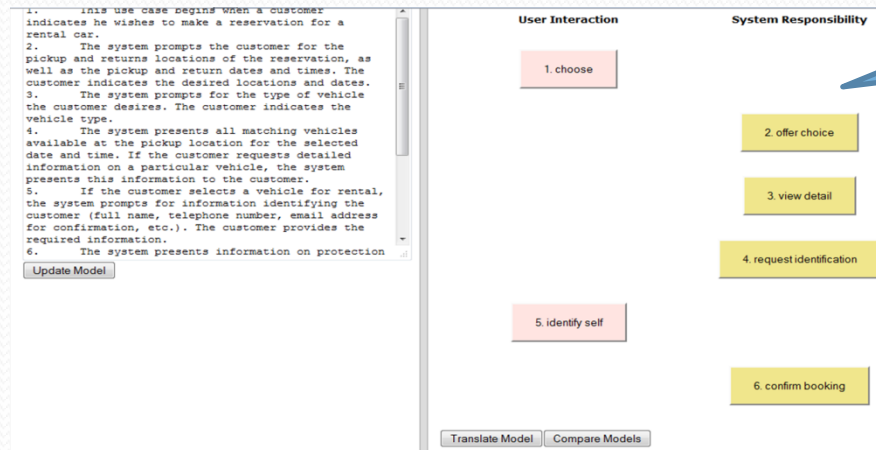
- **Automatically extracted and visualised** the English and Malay requirements as EUC models
- **compare and translate** components → consistency checking
- **Traceability support** to trace the abstract interactions and trace-back an abstract interaction in the EUC model to the essential interactions in both NL requirements
- Inconsistencies are **visualised** using different colours in both languages.
- The requirements model in the EUC of one language, for example English, can be automatically be **translated** to the other language (Malay)-→to check for consistency of naming and to check appropriate interaction sequences in both languages.



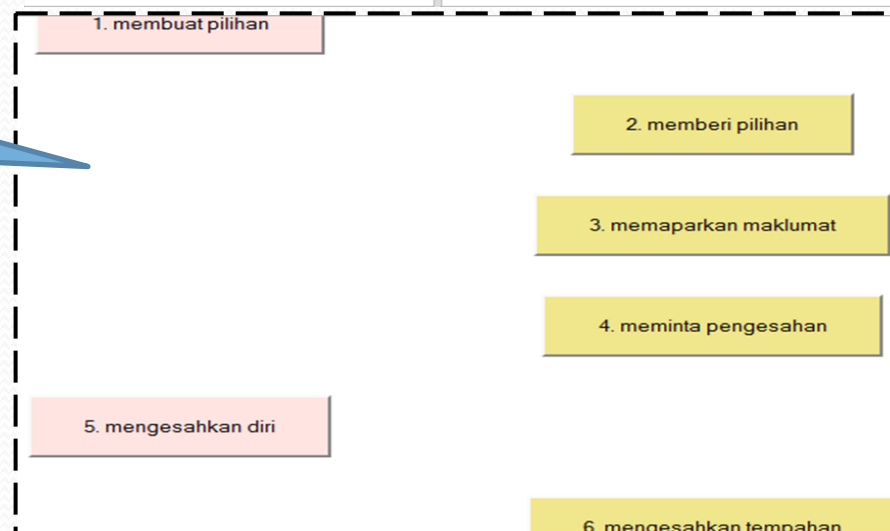
High-level architecture of our MEReq tool.

MEReq: Capture Multi-Lingual Requirements

English EUC Requirements



Malay EUC Requirements

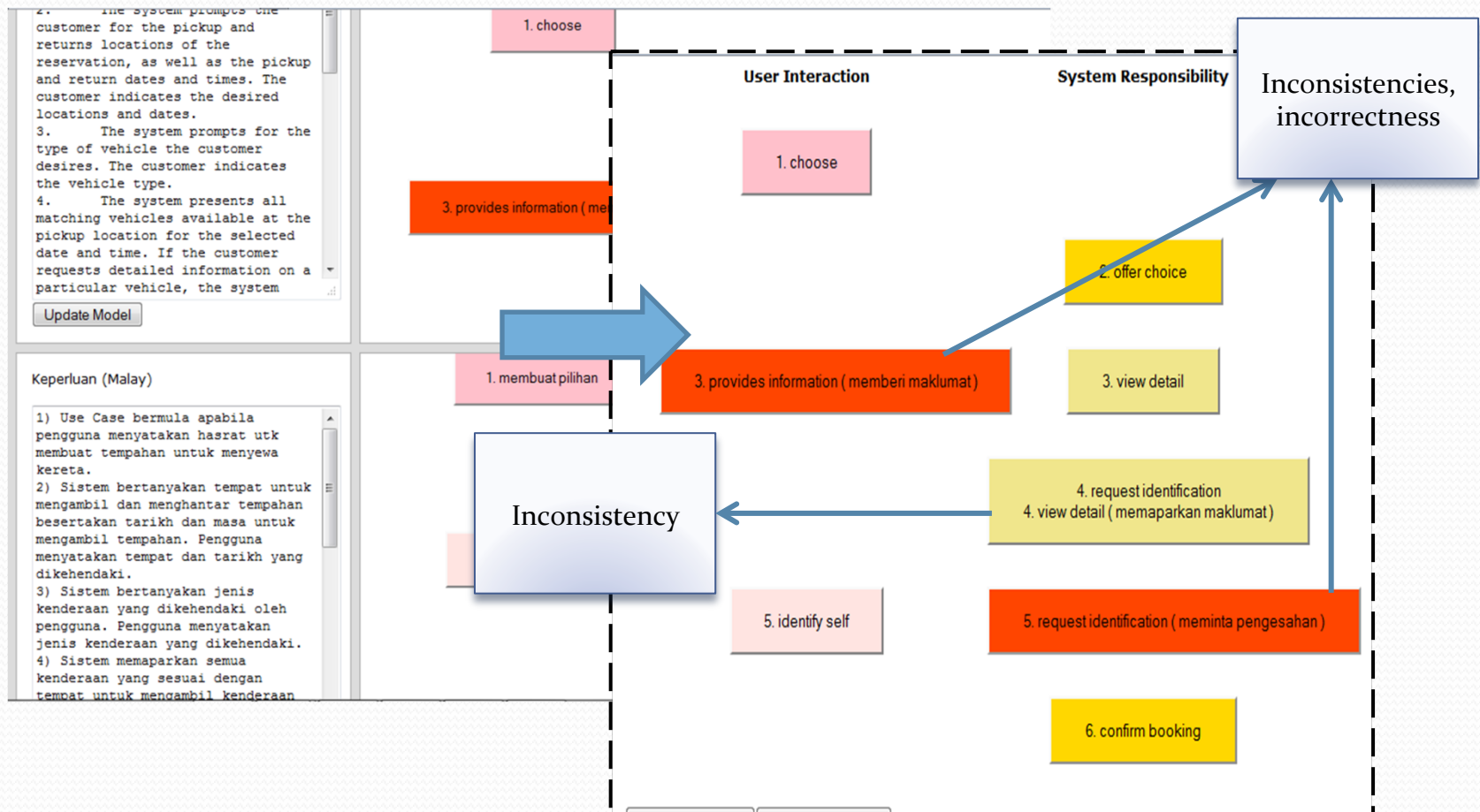


MEReq: Traceability Support

MEReq - MalayEnglish Requirements Capturing and Consistency Checking

Requirements (English)	User Interaction	System Responsibility
<p>1. This use case begins when a customer indicates he wishes to make a reservation for a rental car.</p> <p>2. The system prompts the customer for the pickup and returns locations of the reservation, as well as the pickup and return dates and times. The customer indicates the desired locations and dates.</p> <p>3. The system prompts for the type of vehicle the customer desires. The customer indicates the vehicle type.</p> <p>4. The system presents all matching vehicles available at the pickup location for the selected date and time. If the customer requests detailed information on a particular vehicle, the system presents this information to the customer.</p> <p>5. If the customer selects a vehicle for rental, the system prompts for information identifying the customer (full name, telephone number, email address for confirmation, etc.). The customer provides the required information.</p>	<p>1. choose</p>	<p>2. offer choice</p> <p>3. view detail</p> <p>4. request identification</p>
<p>Keperluan (Malay)</p> <p>1) Use Case bermula apabila pengguna ***membuat pilihan ***menyatakan hasrat*** membuat pilihan*** utk membuat tempahan untuk menyewa kereta.</p> <p>2) Sistem bertanyakan tempat untuk mengambil dan menghantar tempahan beserta tarikh dan masa untuk mengambil tempahan. Pengguna menyatakan tempat dan tarikh yang dikehendaki.</p> <p>3) Sistem bertanyakan jenis kenderaan yang dikehendaki oleh pengguna. Pengguna menyatakan jenis kenderaan yang dikehendaki.</p> <p>4) Sistem memaparkan semua kenderaan yang sesuai dengan</p>	<p>1. membuat pilihan</p> <p>3. memberi maklumat</p>	<p>2. memberi pilihan</p>

MEReq : Consistency Management



Evaluations & Results

- Conducted three studies to evaluate the efficacy and effectiveness of our approach and MEReq tool support
 - 1) Evaluated IT professional and IT student performance in *manual* extraction of EUCs and making them consistent without MEReq
 - 2) Evaluate the usability of MEReq for performing requirements capturing and consistency management tasks
 - 3) Evaluate the efficacy of MEReq in the extraction of essential requirements

Evaluations & Results

Manual study to Capture Multi-lingual Requirement

- conducted two separate quasi-experiments involving 13 Malaysian software professionals and 40 Malaysian undergraduate students. The experiments compared their performance in terms of correctness (qualitative score) and the time taken (minutes) when *manually* extracting multi-lingual requirements (in both Malay and English) to EUCs.

Paired Samples statistics (N=13):Industry data

Variables		Mean	Median	Std. Dev.
Pair 1	EngScore	2.77	3.0	1.24
	MalayScore	2.08	2.0	1.26
Pair 2	ETimeSpent	9.92	9.0	3.97
	MTimeSpent	13.00	13.0	3.06

✓ local IT professionals spend a significantly longer time to capture Malay requirements compared to English requirements.

Paired Samples statistics (N=40):Students data

Variables		Mean	Median	Std. Dev.
Pair 1	EngScore	2.23	2.00	1.14
	MalayScore	2.88	3.00	0.99
Pair 2	ETimeSpent	10.83	10.00	4.49
	MTimeSpent	10.10	10.00	3.76

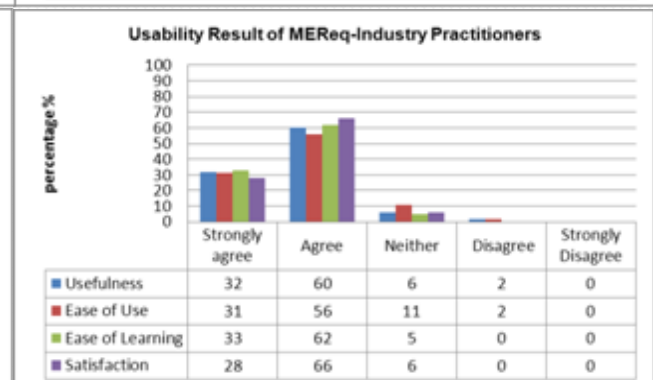
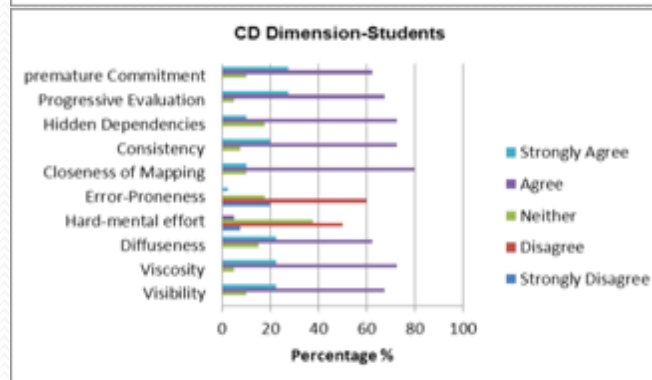
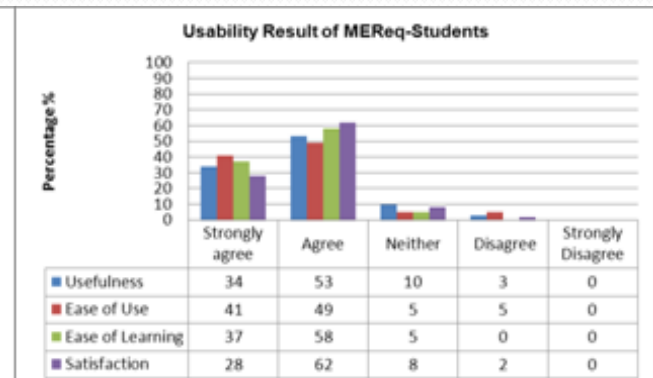
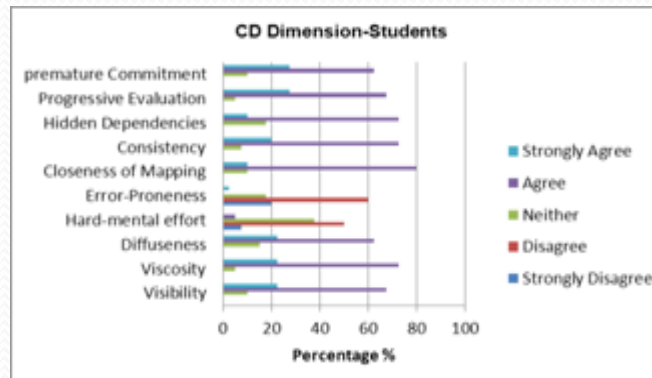
✓ student performance is better when dealing with Malay requirements compared to English.

- correctness ratio for English language requirements is between 37%-46% and for Malay language requirements is between 35%-48%

Evaluations & Results

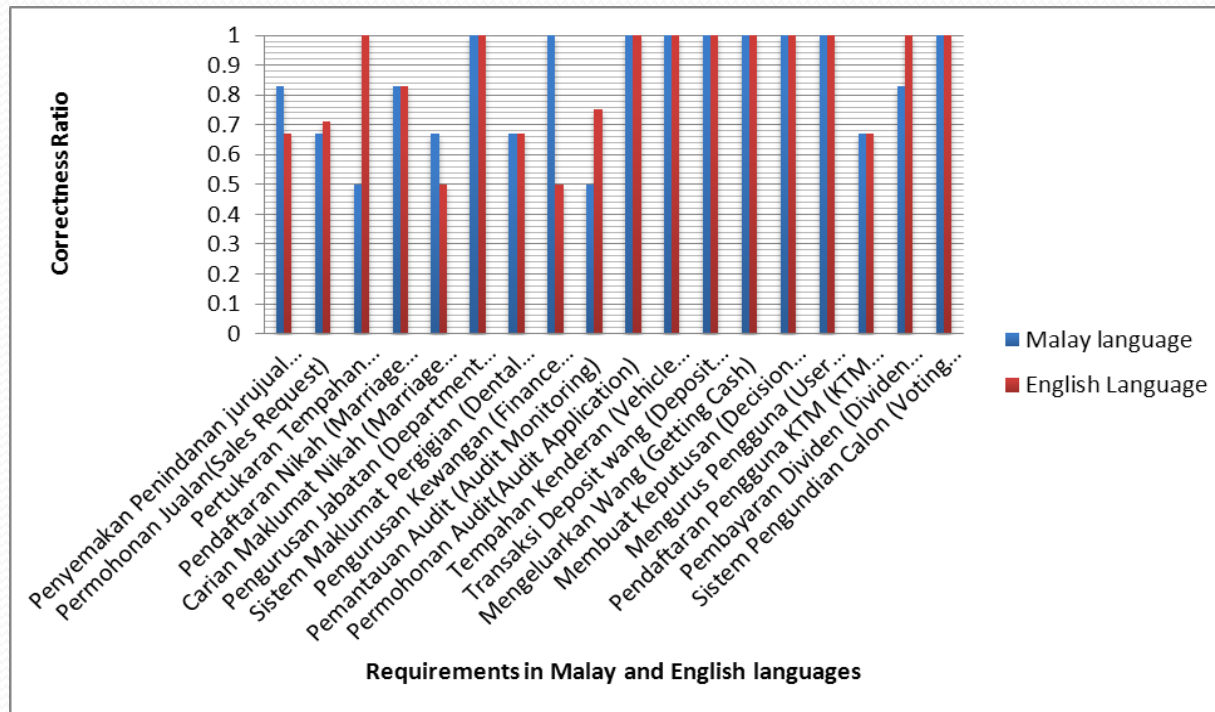
Usability Evaluation of MEReq

Cognitive Dimension	Question
Visibility	It is easy to see various parts of the tool
Viscosity	It is easy to make changes
Diffuseness	The notation is succinct and not long-winded
Hard mental effort	Some things do require hard mental effort
Error-proneness	It is easy to make errors or mistakes
Closeness of mapping	The notation is closely related to the result
Consistency	It is easy to tell what each part is for when reading the notation
Hidden dependencies	The dependencies are visible
Progressive evaluation	It is easy to stop and check my work so far
Premature commitment	I can work in any order I like when working with the notation



Evaluations & Results

Accuracy in Capturing Multi-lingual Requirements



correctness ratio shows significantly better results than the manual study with approximately 85% of correctness for English and 84% correctness for Malay requirements.

Conclusion & Future Works

- MEReq helps to enhance correctness and reduces time when capturing multilingual requirements.
- MEReq tool complements current requirements engineering tools such as RaQuest, DOORS, ReqWiki and Requisite Pro by supporting the process of capturing and checking the consistency of multi lingual requirements.

Future Works:

- Develop a larger library of Malay essential interaction and EUC patterns needs
- Create a pattern editor for essential interactions and abstract interactions to enhance the collection of essential interaction and abstract interaction library patterns.
- To generalise MEReq to support other languages, such as Mandarin
- Incorporate further lessons learned by Hanish and Corbit (2007) which studying cultural differences between multi-lingual team communications, supporting more complex transformations between EUCs in different languages
- Consider to integration ur work of with Google Translate or other NLP frameworks to help support translation of essential interactions.



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