

# Enhancing Effective Interoperability Between Mobile Apps Using LCIM Model

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**Abstract**— Levels of conceptual interoperability model is used to develop the method and model towards enhancing interoperability among mobile apps. The LCIM is used as descriptive and prescriptive form and it also make available of both metric of the degree of conceptual representation that exists between interoperating systems. In descriptive form LCIM is used to decrease the discrepancies in rating mobile apps based on content by suggesting a rating system that is completely based on interoperability. In the prescriptive form it receives information for app development, which allows producing apps with prominent level of interoperability. The Levels of Conceptual Interoperability has the abstract backbone for developing and implementing an interoperability framework that supports to exchange of XML based languages used by M&S systems across the web.

**Index Terms**— levels of conceptual interoperability model, descriptive form, prescriptive form, mobile computing, Mobile apps, interoperability rating. Software engineering

## I. INTRODUCTION

LCIM model not only enhances the interoperability but it also provides a better way to speed up mobile apps. The mobile apps are at present rated based on content. There are no definite approaches to rate the mobile apps on technical terms. Currently many apps that are technically sound are being rejected because of the content they provided so the rating mechanism need to be changed thus soothing the developers. This paper suggests that rating the mobile apps based on interoperability would get to the bottom of the problem by enhancing LCIM model. Mobile device continue to boost in the market with improvement in mobile infrastructure, device affordability and cultural acceptance. However, there is a campaigning trend in mobile application but becoming increasingly focused on applications with less interoperable. On analyzing all the existing interoperability models, it was found that LCIM model used in systems engineering domain can be adapted to get better and effective interoperability of mobile apps. This paper introduces a general model dealing with various levels of conceptual interoperability that goes away from the technical reference models for interoperable solutions. The LCIM is used in both descriptive and prescriptive form. In descriptive the LCIM can be used to describe the levels and properties of interoperability and rate the apps based on interoperability. In the prescriptive role, the model prescribes the methods and requirements that must be satisfied during engineering phases of app development to attain a preferred level of interoperability. The Levels of Conceptual Interoperability Model was evaluated to see at

what level it can support the different necessary artifacts. The LCIM started as a model to make clear the needs, to be specified and also assure interoperation on different levels. Interoperation is only possible - in a meaningful way- if the technical structures are associated with the conceptual ideas. As such, the LCIM is a framework describing a spectrum how this is technically implemented. It request that data (entities, propertyed concepts) and how they are used (process concepts, methods) and the constraints are described by artifacts following the ideas of system architecture and modeling as known from the domain of system engineering.

## II. CONCEPTUAL MODELING AND INTEROPERABILITY

Zeigler proposed a model for understanding a system that is within another observing system. He proposed three main properties that must be supported and they are Perception, Meta model and Mapping.

### *Perception*

Observing system must be able to sense the behavior of the system that is being observed.

### *Meta model*

The observing system must have a Meta model of the observed system.

### *Mapping*

We must be able to map the experiential properties process and constraints resulting into perceptions and Meta models. These three property need to be clear in order for the apps to interoperate efficiently. Thus conceptual models are the best way to express these premises more clearly. LCIM is applied to an idea about its potential and limitations in the current simulation interoperability approaches, in particular the High Level Architecture (HLA) and Base Object Models (BOM). It emphasizes the relevant accurate engineering methods and principles and replaces ad-hoc approaches. A conceptual model is the intangible and simplified representation of systems for some specific purpose by languages, figures, tables, or other suitable artifacts. Robinson defines a conceptual model as "*a non-software specific description of the simulation model that is to be developed, describing the objectives, inputs, outputs, content, assumptions, and simplifications of the model.*" [1] Following Robinson's proposal, conceptual models and conceptual modeling:

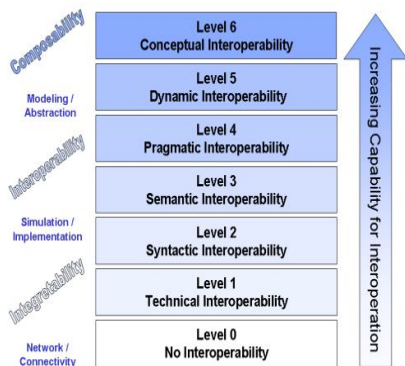
Reduce ambiguity, incompleteness, inconsistency, and mistakes in the description of requirements, Facilitate the communication between stakeholders in modeling and simulation processes, such as users, architects, analyzers, domain experts, modelers, and developers,

Form the basis and start for successive phases (analysis, design, implementation and application), Facilitate the Verification, Validation and Accreditation (VV&A) of models and systems, and Promote the reusability, interoperability, and composability of simulation resources.

Now we observe that conceptualization promotes composability. Composable systems are extremely self contained which means that a system can be deployed independently. The module will work together with other component but the dependant components are replaceable. Stateless means that the components indulge the requests from other components independently and the requests are not connected to any previous requests. When apps interoperate efficiently they must be self contained and stateless, which can be effectively achieved through conceptual modeling. LCIM was chosen as a successful model for enhancing interoperability among mobile apps as it basically depends on conceptual modeling and makes the apps composable.

### III. LEVELS OF CONCEPTUAL INTEROPERABILITY MODEL

LCIM was initially proposed by Tolk and Muguira [2]. After continuous evolution, it forms the latest version illustrated in Figure 1. The seven levels from “no interoperability to conceptual interoperability” is notated from L0 to L6, whose implications are listed in Table 1. Bottom-up refers to from L0 to L6, top-down vice versa. Besides the simulation interoperability community, LCIM is used by scientists of various disciplines to contract with troubles in their communities, e.g. system biologist and ontology researchers.



**Figure 1.** The Levels of Conceptual Interoperability Model  
The Levels of Conceptual Interoperability Model (LCIM) was evaluated; to what extent it can support different necessary artifacts. The results are based on research that tried to create the different features highlighted in various publications on the LCIM into an overview and to obtain new insights. It is first used as an outline for conceptual modeling. Second, its applicability as a persuasive, as well as a prescriptive model is evaluated. Finally, it is useful to give the impression of being at current simulation interoperability standards, in particular the High Level Architecture (HLA) and Base Object Models (BOM).

### IV. INITIATE A SYSTEMS ENGINEERING FOR APPS INTEROPERATION

Systems engineering defines a lot of principles that maintain the design of systems and documenting their functionality and interfaces in a way ensuring that independently designed systems can interoperate with each other. This section, we will initiate the ideas of conceptual modeling and capturing the resourceful artifacts in a way, using the LCIM as the guiding frame, in support of App interoperation.

### V. DESCRIPTIVE AND PRESCRIPTIVE ROLES

Systems engineering distinguishes between explaining (descriptive) and mandating (prescriptive) models. LCIM can serve in both functions [3]: In descriptive role, LCIM describes the levels and properties of interoperability existing in a given app. In the prescriptive role, LCIM prescribes the methods and requirements that must be satisfied during the engineering of an app to achieve a desired level of interoperability. Referring to the definitions of descriptive linguistics [4] and prescriptive linguistics [16] in addition to the definitions of descriptive and prescriptive models by Department of Defense (DoD)[5], the definition of descriptive and prescriptive roles of LCIM are defined and their relationship is clarified.

#### *Descriptive Role*

Developers brand their applications according to Google Play ratings system, which consists of four levels, Everyone Low maturity, medium maturity, high maturity. The apps get discarded due to the content they provide even they provide the users with a lot of technical comfortness. Descriptive form of LCIM allows us to rate them based on interoperability. The definition of descriptive model by the DOD [5], characterizing the descriptive function of LCIM used to depict or analyze the ability, properties, characteristics and the levels of conceptual interoperability of an existing system or system of systems In prescriptive role, LCIM serves as documentation and maturity model, the goal of descriptive role describes how existing systems are interoperating and what level of conceptual interoperability can be reached by user's detailed approaches without prescription. In descriptive role, LCIM is used to show the gaps that need to be closed.

The characteristics of the descriptive role are listed as:

Real systems or system of systems that have been implemented or existed;

The specific technical approaches, implementations and documentations are known;

LCIM is used as a maturity model. The lower levels must have been satisfied; When they reaches higher levels.

The levels are common compassionate bottom-up. The lower level is the idea of the higher and the higher needs the implementation of lower levels.

The processes of descriptive role describe the documentation, specific approach, and implementation of interoperating systems from L0 to L6 according to Table 2, and evaluate the levels they have reached.

**Table 2.** Descriptive Role of LCIM

Levels	Description of Interoperability at this level
L6	Interoperating apps at this level are completely conscious of each others information, processes, contexts, and modeling assumptions.
L5	Interoperating apps can also reorient information formation and using based on understood changes to meaning, due to changing context as time increases.
L4	Interoperating apps is aware of the context (system states and processes) and meaning of information being exchanged.
L3	Interoperating apps are exchanging a set of terms that they can semantically parse.
L2	Apps have an established protocol to exchange the right forms of data in the right order, but the meaning of data elements is not recognized.
L1	Apps can exchange data e methodological connection(s)
L0	NA

**Prescriptive Role**

The mobile apps need to be modeled and implemented in a systematic way so as to boost interoperation among them. The prescriptive form of LCIM guides to build our app in a structured way which makes the apps to reach a high level of interoperability. It also prescribes the approaches and requirements that must be satisfied to accommodate a target degree of conceptual representation between systems.

The characteristics of the prescriptive role are listed as the following: Real systems or system of systems do not continue living in the phase of theoretical modeling; As an interoperability guidance model, LCIM is used to suggest the required conditions and potential engineering approaches to reach a certain interoperability level; Top-down mappings are required from formation to implementation. If problems are dealt at the conceptual level without any real systems, the lower levels are unreachable until real systems are implemented; The levels are equally supportive bottom-up, mapped, and refined top-down. Higher levels need the implementation of the lower, so there is much work to do for the mapping from the higher to the lower; Getting the higher level is not adequate, full band interoperability at all the levels is needed in particular for the prescriptive role of LCIM; As the advance of techniques, the suggested approaches by the prescriptive role are always varying and embryonic and only have proportional constancy in a certain period. The contents of prescriptive role at each level are illustrated in Table 3. From which Ontology, Unified Modeling Language (UML), Model Driven Architecture (MDA), and Discrete Event System Specification (DEVS) are the important approaches to develop the conceptual interoperability and composability. The prescriptive role of LCIM is used to facilitate the transformation from conceptual modeling to systems implementation focusing on the interoperation aspects. LCIM is a guide - or check list - how to reach the target. In this case, it builds logically top-down.

**Comparison and Relationship between Descriptive and Prescriptive Roles**

The descriptive and prescriptive roles apply to LCIM through different viewpoints. To reach semantically lossless interoperation, all levels are needed in both cases. Description and prescription have differences and similarities as illustrated in Table 4. The combinations can facilitate better solutions to interoperation and composition problems. There are two kinds of combinations. Prescription can be first used with the analysis to the interoperation objectives, costs and conditions. Next descriptive role can be used to estimate the interoperability of that process. The prescription - description - prescription again - description again iterative cycle can be based.

be used for the solution. The other kind of combination is reuse-

Some systems or subsystems have existed or been implemented and need to be integrated to reach a certain interoperation goal. The description and evaluation - prescription - objective execution - description - evaluation iterative cycle can be used. In both cases, LCIM can be seen as the two sides of a coin - one is what exist or have done, the other is what needs to be done. LCIM is a good theory or model to evaluate the levels of interoperability.

**I. CONCLUSION**

This paper will describe a framework that will merge the various specification schemes and apply a methodology to define the structural variances between components. The mobile apps are facing many challenges in their interoperation; the limited resources significantly impede the improvement of interoperability between mobile apps. In LCIM the apps can be rated based on interoperability. Apps of different vendors can interoperate efficiently and effectively when LCIM is followed while implementation. When vendors permit users to interoperate apps with third party module, this allows users to manage their apps more efficiently instead of downloading lots of apps. This helps users to select apps from different vendors as a choice of sticking to apps of single vendor.

**Table 3.** Prescriptive Role of LCIM

Levels	Prescription of Requirements to reach this Level	Common Reference Engineering Approaches
L6(Conceptual)	A shared understanding of the conceptual model of a system (exposing its information, processes, states, and operations).	DoDAF; Military Mission to Means Framework; Platform Independent Models of the Model Driven Architecture; SysML
L5(Dynamic)	The means of producing and consuming the definitions of meaning and context is required.	Ontology for Services; UML artifacts; DEVS; complete UML; BOM
L4(Pragmatic)	A method for sharing meaning of terms and methods for anticipating context are required.	Taxonomies; Ontology; UML artifacts, in particular sequence diagrams; DEVS; OWL; MDA
L3(Semantic)	Agreement between all systems on a set of terms that grammatically satisfies the syntactic level solution requirements is required.	Common Reference Model, Dictionaries; Glossaries; Protocol Data Units; RPR FOM
L2(Syntactic)	An agreed-to protocol that all can be supported by the technical level solution is required.	XML; HLA OMT; Interface Description Language; CORBA; SOAP
L1(Technical)	Capability to produce and consume data in exchange with systems external to self is required.	Network connection standards such as HTTP; TCP/IP; etc.
L0(No)	NA	NA

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