

## Digital Transformation of Virtual Enterprises for Providing Collaborative Services in Smart Cities

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**Abstract.** Municipalities are digitally transforming urban environment into smarter cities aimed at addressing urban growth and social challenges. This transition of urban space influenced by Information and Communications Technology (ICT) enables novel business models and Virtual Enterprises (VE) processes. Presently, there is need to provide insights into the state-of-the-art of VE and development of digital transformation in order to improve services provided to citizens and stakeholders in smart cities. Therefore, the aim of this study is to employ ArchiMate as the modelling language to demonstrate the digitalization of VE to depict how VE collaborates in smart cities. Evidence from a focus group discussion was modelled in ArchiMate to present findings on how VE can be digitalized to provide collaborative services. Implications from this study provide insights to guide VE to understand the imperative need of digital changes in smart cities.

**Keywords:** Digital transformation; Virtual enterprises; Collaborative services; Smart cities; ArchiMate language.

### 1 Introduction

A city is a permanent and large human environment which provides several opportunities and services to its residents [1]. Cities are currently improving performance and quality of urban services by deploying digital, intelligent, and smart approaches [2]. Accordingly, municipalities are exploring solutions to provide services in a sustainable, resourceful, and responsive method for its citizens [3]. Digitalization is pushing municipalities beyond its conventional limits and also providing opportunities to improve services productivity provided to citizens [4]. The concept of smart city aims to deploy digital technologies to support better development and administration within city operations [5]. Digitization refers to the process of adapting analog information into a digital format [6]. Respectively, Digital Transformation (DT) refers to the use of technologies, and its competences to digitize institutional assets [7].

DT of enterprises in urban environment support cities in achieving a balanced ecosystem [8]. DT involves changing of an organization or community in delivering

better services or products through Information Technology (IT) as the core element. DT promotes better collaboration and communication among Virtual Enterprises (VE) that provide services in smart cities [1]. Since the notion of VE first appeared in late 1980s [9], VE has been distinguished from a simple integration and collaboration of businesses as technology-driven dynamic coalitions formed based on the use of Information Systems (IS) [10]. Presently, urban services are characterized by unanticipated and often dramatic changes. In this challenging and difficult situation, stakeholders and partners must develop and implement innovative and new strategies to provide services to citizens [11]. Amongst the most inventive initiatives being employed by enterprises in cities sphere is the concept of VE [12].

VE refers to a virtual establishment which comprises of independent merchants, competitors, clients involved in a temporary collaboration or network organization using IT to share cost and technology to address current market demand in exploiting specific opportunity [13]. Moreover, VE can be said to be a temporary alliance of organizations with similar capabilities that co-operate in sharing resources and core competencies to respond to business prospects, and whose collaboration is facilitated by Information Communications Technology (ICT) [14]. Additionally, VE is a synergetic combination of dissimilar companies that liaison to realize specific business goal within a specific time at a reduced cost [15]. The physically dispersed organizations work together to fulfil their set goals by exploiting ICT to provide value-added benefits to clients [5]. The success of VE dynamically relies on participation of the members in sharing and creating knowledge across disciplinary, cultural and/or spatial boundaries either in real-time or asynchronously [16].

VE have lately received much attention due to the changing needs of business community and advancement of technological inventions [13]. Therefore, VE has become essential for continuous business survival in emergent business sector to increase competitiveness, optimize resource use, and increase business scale [14]. But, to achieve an interoperability, responsiveness and agility of VE operations [17], in smart city, a method is needed to provide modelling concepts that support the illustration of VE business process across different layers, granularity, abstraction and phases [18]. Currently, there is limited methods that mainly facilitate the modelling of VE business models in a holistic approach [19]. Furthermore, fewer studies have investigated the potential impact of DT of VE on value creation in the smart city context. An appropriate approach is needed to examine VE in providing services in urban domain [20]. Due to disruptions from digital transformation and nature of VEs, it is required to design models to help explore the progression of DT and VE in smart cities [19]. Thus, this research attempts to resolve the following research question:

**RQ.** How can DT aid in providing collaborative services amongst VE operating in smart city context?

Therefore, this study provides insights into the state-of-the-art of VE and development of DT in order to improve services provided to citizens and stakeholders in smart cities. ArchiMate is employed to model VEs business process in providing collaborative services in smart cities, which is focused on the DT of VE. The remainder of this study is structured as follows. Section 2 is theoretical background. Section 3 presents the methodology. Section 4 is ArchiMate modelling of VE. Section 5 is the discussions and implications. Section 6 is the conclusion.

## 2 Theoretical Background

This section discusses on the background of smart city, overview of VE, characteristics of VE, life cycle of VE, digital transformation of VE in smart cities, and related works.

## 2.1 Background of Smart Cities

Cities involve multifaceted systems which comprises of different citizens, stakeholders, housing, physical infrastructure, utilities, economic activities, and services [6]. With approximately four billion people residing in cities presently, an international trend of digital-based growth is taking place [21]. This change is driving policy innovations for novel technological implementations and data-oriented approaches aimed at addressing environmental, social problems and urban growth [4].

Thus, municipalities are working to make their cities smarter. Where a smart city as stated by the United Nations (UN) is an innovative city that deploys ICT and other mediums to enhance the quality of life, productivity of urban amenities, and affordability [5], while confirming that it addresses the requirements of present and generations to come in relation to environmental, economic, and societal aspects [1].

Smart cities can bring about future environmental, financial, and social benefits supported by digital technological innovations [22]. Making city smarter aims to adopt urban polices mostly aligned to resource monitoring, effective administration, strategic design, implementation, and control activities in an urban space to improve liveability, efficiency, and sustainability [3].

## 2.2 Overview of Virtual Enterprise

The term virtual enterprise is attributed to Mowshowitz [9], who aligned VE with virtual memory used in IT system processing. But, VE gained its current prominence for organizations from Davidow and Malone's study [23]. Also, researchers such as Byrne Week [24] defined VE as a momentary network of independent establishments to share costs, knowledge, and access to members market based on a common business understanding [20]. VE concept has emerged progressed in response to globalization and coming of the digital age. The characteristics of VE that distinguish its formation from traditional businesses are discussed as seen in Table 1.

**Table 1.** Characteristics of virtual enterprise

Characteristics	Description
Virtuality	VE deploy ICT that enables geographically dispersed businesses to connect with each other in achieving mutual business goal [14]. ICT is deployed to support the coordination of each members owned assets [12] and decreases transaction costs [11].
Dynamics	VE are mostly dynamic, short lived [12], and all partners have same rights where there is no leading enterprise in the consortium [11].
Flexibility	VE have tactical goals to exploit adaptability towards societal changes [12]. Thus, VE has a flexible logistic structure with rules that renders it to be adaptable. An enterprise can leave or become a member in the network at any time [11].
Autonomy	VE are able to adapt to fast changing environment to support flexibility in achieving an effective business collaboration and information flows to enable an automatic negotiation and decision making system [14].
Heterogeneity and immobility	VE is joined based on the individual resource and skills of different business by sharing different data and competence to achieve viable advantages in a short run [14].
Focus on core competencies	In VE each firm participates with its competence, which is matches up to other businesses' skills. Also, every partner firm backs the VE with its own core resource, thereby enabling excellence products and services [11].
Opportunity driven	In a VE participating businesses work collectively to achieve specific opportunities. This creates a means for innovation which enables VE to respond efficiently and rapidly to changing market demand [11].
Semi stable	A less-formal associations of dependence are formed among the businesses so that they

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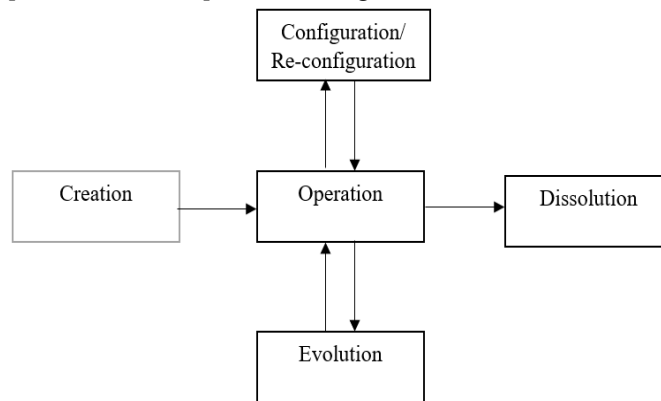
relationship	survive in the market without the VE consortium [11].
Trust	A significant feature is the degree of trust among businesses [15]. Trust influence partners intention of sharing information within the strategic alliance network, which also render enterprises to be more interdependent [11, 16].

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VE is a predominant area that is usually referred to as an extended enterprise or virtual corporation [19]. Accordingly, VE is a dynamically reconfigurable networked of enterprises that shares information and/or knowledge, resources and processes to meet a fast changing window of opportunities [10, 12]. Although, VE consists of several enterprises, the service they provide appears as a sole service to the society. Thus, its internal process resembles a decentralized enterprise [11, 20, 25].

### 2.3 Virtual Enterprise Life Cycle

Since the inception of VE there has been much discussion regarding its life cycle which comprises of creation, operation, continuation/reconfiguration, evolution, and dissolution [10, 11, 12, 18, 19], as seen in Figure 1.



**Fig. 1.** Virtual enterprise life cycle

Figure 1 depicts VE life cycle, each of the process are discussed below;

The *creation phase* starts when a new business prospect is identified. Thus, it is required to rapidly plan an appropriate virtual firm by identifying associates and establishing cooperative contracts [11]. The creation phase forms a group of partners to achieve a commercial process [12]. The creation phase involves *searching for partners, negotiation, and establishment of legal agreements*. *Searching for partners* involves publishing notice of the specifications of VE's needs, including all the requirements such as quality, technical aspects, and inclusion of enterprises who meet the minimum standards stipulated [12]. *Negotiation* is employed to select associates based on a given period, value, and price grounded on a pre-defined objective [12]. *Establishment of legal agreements* involves the signing and legalizing of contract associated with VE consortium to legalize the partner agreements reached [12].

*Operation phase* is invoked when business members perform business operations in achieving their mutual goal. In this phase the supervision of the project is carried out to resolve issues if any [12]. Additionally, collaborative business processes are employed and continuously monitored for VE to adopt to changes [19]. *Evolution* involves the re-defining of existing applied models to be more effective based on internal situations by optimizing business scenarios [19].

*Configuration/re-configuration* defines the method utilized to design VE models such as the information, systems, resources, etc. [19]. This phase also involves specifying enterprise processes and scenarios, specifying technologies, systems, and shared resources required to develop VE models [12]. Lastly, the *dissolution phase* begins when VE accomplishes the implementation of its set goals. The dissolution phase aims to dismantle the coalited enterprises [12].

This current study will only consider the creation and operation phase of VE in smart city as seen in section 4.2 of this paper.

## 2.4 Digital Transformation of Virtual Enterprise in Smart City

According to Oxford dictionary digital refers to digits of “0” or “1” that indicates a data or signal. Digitize is the format of depicting information as “0” or “1” to be utilized by compilers [6]. DT involves conversion of analogue into digital information. It describes the act of converting information from analog to digital which can result to change in business model towards providing novel revenue stream as well as new value suggestions [26]. Presently, the society is experiencing the transformative impacts of digital disruption such as data analytics, machine learning, social media, mobile computing, cloud/fog computing, artificial intelligence, robotic process automation, internet of things, blockchain and other technologies at a highly accelerated pace [8]. DT is an integration of business models and innovation [27].

DT establishes new links inside VEs by streamlining the operations, growing the businesses and supporting customer relationships. There is no doubt that digitalization is here to stay [27], it's no longer an option, but its inevitable [28]. In urban context, DT involves a rudimental change in the way enterprises in cities functions with innovative strategies, to address citizen's needs, who are consumers of the services via wearable technologies, mobile devices, or other devices [27]. Also, enterprises in cities needs to redesign the services by keeping the citizens as the concentration and with detailed strategies towards digitizing the processes that reduces human dependency [26]. Hence, VEs in smart cities are embarking on DT of their business processes to improve profitability and competitiveness by business processes, making information, and product/services available in digital forms [6].

## 2.5 Related Works

Over the decades a few studies explored VE based on Enterprise Architecture (EA) perspective among these studies Petersen et al. [29] explored on achieving value added services in VE and data based on EA for smart cities. The researchers developed an EA framework to support VE in cities for utilizing data to create value added services. Mouhib et al. [30] suggested adopting EA to improve VE modeling in addressing complexity and uncertainty of VE. Their study identified the requirements of VE modeling. Noran [17] examined how to improve collaborative agile healthcare synergy. The author aimed to improve interoperability and cooperation of participants grounded on collaborative networks and EA life cycle-based paradigm enabled by EA. Kim et al. [19] implemented a modeling approach for interoperable and agile VE to supports all facets of VE modeling in an elegant method to achieve an integrated synergy effects for domain experts.

Perrin and Godart [31] designed a model to enhance collaborative work in VE. The authors aimed to provide adequate information support for cooperation and coordination among VEs. Aerts et al. [32] developed a flexible agent-oriented ICT architecture for VE to improve the requirements for achieving an agile enterprise that utilizes ICT support. Petersen et al. [13] proposed an agent-based approach to model VE, deployed for assisting co-operative work among remote partners. Their study aimed to achieve a standardised modelling during the life cycle of VE. Camarinha-Matos et al. [10] presented an architecture for VE. Among the review studies there is lack of research that employed a modelling approach to demonstrate the digitalization of VE in smart city context to provide collaborative services. Hence, this current study addresses this setback.

### **3 Methodology**

This study employs focus group discussion to collect data for DT of VE in providing collaborative services in smart city. Focus group discussions was used as the primary source of data as it enables researchers to understand participant descriptions and accounts of events and actions [22, 33]. Accordingly, this study collects data from an organization and a municipality in Norway based on the recommendation of Creswell and Poth [34], by employing focus group discussions to improve empirical grounding of the domain investigated.

Before the focus group sessions, the interviewers prepared a model of an architecture similar to Figure 2 to ensure that all vital issues were discussed during the session. Then after each session, the interviewer's presents models from the discussions. The models for each session were then refined, confirmed and illustrated in ArchiMate (see section 4.2) analogous to prior study [35] to depict DT of VE in smart cities. Besides, this study adheres to Norwegian Centre for Research Data (NSD) ethics guidelines and the names, organization, and current title of contributors is removed in this study, hence all informants are anonymous.

## **4 ArchiMate Modelling**

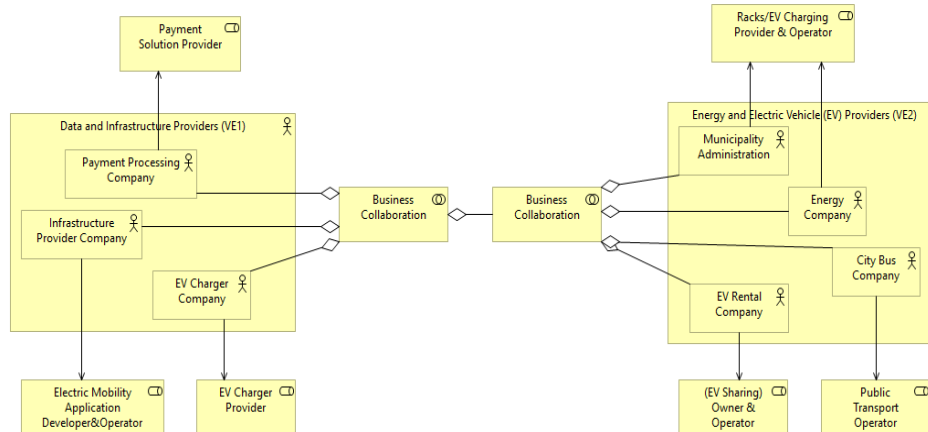
### **4.1 Overview of ArchiMate Modelling**

In information system enterprise modelling language describes how an enterprise develops and provides value represented from a high abstraction level. Enterprise modelling language defines business operations and illustrates how activities are achieved by deployed systems and technology [36]. Several enterprise modelling languages exist such as 4EM, Unified Modelling Language (UML), semantic object model, integrated enterprise balancing, etc. but are unfeasible. This is because they are inadequate in expressiveness when describing digital enterprise ecosystems. Thus, there is need for an enterprise modelling approaches that can be extended or evolved in order to carter for current and emerging development developments such as DT. Respectively, the ArchiMate modelling language was selected to be employed in this study to model DT of VE in smart cities. Also, ArchiMate is selected in this study as a modelling language because it supports a high-level concept that focuses on business and how it can be aligned and mapped with the IT strategy.

ArchiMate Version 1.0 was first announced on February 2009 by the Technical Standard after it was formally approved by the Open Group. ArchiMate is a modelling method which differentiates between a business layer, an application layer, and technology layer. ArchiMate is an open, free and independent tool for description of enterprise architectures [35]. ArchiMate is designed for modelling enterprise architectures based on 56 different elements and relationships notations in its current version 3.0. ArchiMate supports enterprise architects to examine, define, and visualize the relationships and dependencies among business domains in an explicit way and enables modelling defined by The Open Group Architecture Framework (TOGAF), an established enterprise architecture methodology adopted by leading organizations [37]. ArchiMate is simple but comprehensive in providing a structuring tool for architecture in layers and aspects. The ArchiMate meta-model involves of 3 types of elements which includes active structure elements, behaviour elements, and passive structure elements [35].

## 4.2 ArchiMate Modelling of VE in Smart Cities

This sub-section depicts the application of ArchiMate to present findings from the focus group discussion on digital transformation of creation and operation phase of VE in providing collaborative services to citizens and stakeholders in smart city as seen in Figure 2 and 3. Figure 2 illustrates how VE explicitly collaborates in smart cities. Also, Figure 2 explicitly describes the creation phase of VE illustrating how individual enterprises in VE1 (payment processing company, infrastructure provider company, and Electric Vehicle (EV) charger company) and VE2 (municipality administration, energy company, city bus company, and EV rental company) which collaborates to create and provide services to citizens and stakeholders.



**Fig. 2.** ArchiMate business layer for creation phase of VE

Furthermore, Figure 3 depicts the operation of VEs in the business layer in relation to technology, application and motivation layers based on ArchiMate in providing collaborative electric mobility service in smart city. Also, Figure 3 describes the relationships between business services, applications and technological infrastructure adopted for DT of VE in smart city context structured based on business, application, technology, and motivation layers. Therefore, each layer delivers services that aids the operation of the upper layer [36].

The motivation layer captures the requirement which is to achieve the DT of VEs in providing electric mobility services by various partners. Next, the business layer comprises of the internal and external business operations in providing business products and services (electric mobility service and other digital services) to the city's citizens. These business services as seen in Figure 3 and 4 are achieved by business operations that utilize and transform each enterprise roles which are executed or assigned by business actors in VE1 (data and infrastructure providers) and VE2 (energy and EV provider).

As seen in Figure 4 the application layer illustrates the interaction of several business process carried out by VEs supported by system applications. The system applications comprise of smart mobility backend, electric mobility application, other smart applications that uses data from multiple data sources. The technological layer describes how the aforementioned applications are supported by data technologies and energy technologies that process, communicate, and store data from electric mobility assets, public transport vehicles, and charging facilities.



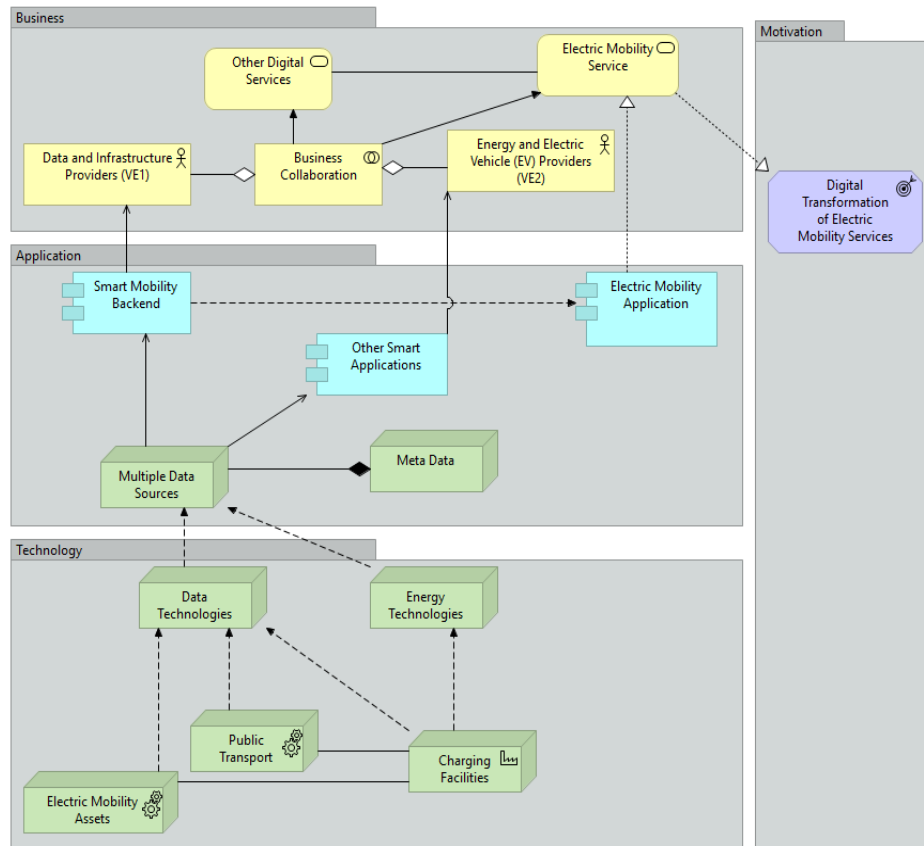


Fig. 3. ArchiMate metamodel view for operation phase of VE

#### 4 Discussions and Implications

This study extends the idea of DT by employing enterprise modelling approach to design and manage city components and processes. ArchiMate is employed for modelling VE because it can model enterprise structure within layers, showing all the components and their dependencies, visualize the relations between businesses. ArchiMate is easily understood by both IT/business experts and non-experts, possible to visualize models in views, personalized for specific stakeholders with definite information requirements. Additionally, ArchiMate is adopted in this study to illustrate the DT of VE collaborating in providing services in smart cities. Based on the modelled findings from the focus group discussion this study provides implications to help municipalities and businesses manage the complex process of DT of VE.

The creation and operation phase of VE shown in Figure 3 and 4 provide insights on how several partners in smart cities can collaborate to provide value added electric mobility services. Additionally, this current study provides a comprehensible enterprise modelling approach that supports the representation of VE operations and process from different views and levels of abstraction during operation phase of VE. Findings from this study presents an abstract graphic language to provide insights to business domain experts or business managers in designing and managing collaboration of partners involved in providing urban services. This study adds to prior research on DT and VE by enabling communications among different stakeholders and would contribute significantly to improve collaboration of VE in improving electric mobility service in smart cities.

## 5 Conclusion

This study demonstrates the digital transformation of virtual enterprise to provide collaborative services in smart cities. Data from focus group discussions was modelled in ArchiMate. Implications from this study provide insights to guide enterprises to understand the imperative need of digital changes in provision of collaborative services in smart cities. Findings from this study can help for developing and maintaining business components and improving collaborative enterprise processes in smart cities. Besides, the findings can be systematically used by IT/business experts to digitally design VE. Also, findings from this study will be useful to researchers who might want to better understand practical implementation of VE model into real society, economic and social context, focusing on smart cities.

Additionally, DT supports VEs in breaking silos of competences to build new bridges and collaboration taking advantages of digital potential for city development. Although, this study contributes to model the DT of VE in smart cities, it is faced with a few limitations. First, only the creation and operation phase of VE are covered in this study, the configuration/re-configuration, evolution, and dissolution phase are not addressed. Secondly, different modelling languages for describing collaborative services are not compared. Future work will involve investigating the stakeholders such as municipality who drives DT of VE in smart cities and how such transformation relates to other sectors such as the technological sector to the business sector etc. Also, comparison of different modelling languages for describing collaborative services will be carried out. Lastly, other phases of VE will be modelled.

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