An Integrated Framework to Quantify Strategic Diversifications in Real-Time Enterprise Industrializing Alliances of Big Data Architecture

Vikas S. Shah

Abstract—**Recent advancements in digital technologies (DTs) have fundamentally enabled collectives to collaborate on analyzing, disseminating, and leveraging the data for many enterprise-wide applications. Real-time access to changing characteristics of analytical information is critical for an enterprise to run a competitive business and respond to a dynamics of marketplace. Enterprises are predominantly recognizing that business processes (BPs) are the driving force in developing new innovations and competitive strategies to enable appropriate Big Data Architecture Patterns (BDAPs) such that the critical and sustainable factors are in the existence of entities. The integration of BDAPs with BPs can become a centralized instrument for enterprises in accurately construe business scenarios. The generic BDAPs are immature and requires a vast amount of BP performance data in order to support a valuable analysis with highest level of granularity. Existing alliances between BDAPs and BP lifecycle are daunting to rationalize characteristics of a real-time enterprise. In this paper, we recognize that as enterprises become more BDAP driven, it's only natural that those insights find their way into the BPs that can place them into action. We provide an approach to derive and customize BDAP for specific BP association to timely delivery of the required information and regardless of the underlying concerns of the DTs. We illustrate the ability to accustom the solution that sustains real-time capabilities of an enterprise in presence of anticipated BPs' performance objectives utilizing BDAPs.**

Index Terms—**Big data architecture patterns (BDAPs), business processes (BPs), digital technologies (DTs), degree of coverage (DoC), real-time enterprises (REs).**

I. Introduction

Emerging DTs are increasing the visibility across the boundaries of enterprise to utilize big data platform [1] at diversified aspects of BPs. Products and services are not confined to established BPs as well as marketplace opportunities [2]. Never the less, new BPs are required to be recognized based on the advancements in DTs. These systems increasingly relates to big data significant domains such as predictability and consumer expectations [3]. They are dynamic socio-technical systems due to characteristics of fluidness and working enterprise, and technologies are intertwined within them. Electronic commerce (e-commerce) platform, Healthcare system, science network, and talent acquisitions are just a few examples of applications.

REs that are associated with such applications uses BPs, the solutions and decisions to ensure that latest information about its consumers, products or services, vendors, employees, and partners is always available and of the relevance [4]. Enterprises can respond to changing consumer expectation, market conditions, and approaching competitive threats more effectively during the advancements in DTs. To expedite the responsiveness, BPs are involved in real-time or near real-time information [5] and [6]. Few examples are real-time insurance policy quote generation, interactive and personalized discounts during consumer navigation, alerts to reaching established threshold, and point-of-sale. All of these can be achieved through enabling BPs [7] that are diversified and associated with real-time information from all the sources and in their classification.

However, REs fail to move beyond existing theories and routine applications to confront the dynamics between the BPs and big data initiatives. We discuss the correlation between BPs and big data to make this turn and to better understand the complexities of big data technologies and patterns. The interaction in digital environments creates tremendous data that are required to be considered beyond boundaries of an enterprise. The examples are plenty, third-party associative data, social platform's behavioral data, and mobile application specific data. Altogether different BPs or critical diversifications are mandatory, with novel classification techniques [8] and with an efficient and effective big data patterns in the context of BP. Consider an example of the smart city infrastructure, when real-time integration between justice department data with the mobile utilization data is acquired, it is perpetually possible to notify policy enforcements as well as new policies during the travelling to another state based on the behavioral analysis of individual. It needs new level of BPs to be introduced based on the identified BDAPs [9], [10], and [11].

In this paper, we propose an approach to correlate BDAPs to evolve REs during the advancements of DTs. We begin by looking at types of requirements (for DTs) that impacts the REs due to big data patterns. To simplify the complexity of big data types, we provide an approach to classify big data according to various paradigms that eventually provides guideline to establish BDAPs. These patterns determines the appropriate BP activity to correlate or introduce. Essentially, we presented an integrative framework to progress RE, irrespective of the type of data generated due to DTs. We present principles to sustain characteristics of RE and evaluation methodology to keep pace with upcoming digital environment in the form of degree of coverage (DoC).

The paper is organized as follows: Section II describes

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Vikas S. Shah is with Connect Enterprise Services Consulting, Wipro Technologies, East Brunswick, NJ, USA (e-mail: vikas.shah@wipro.com).

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identified primary factors impacting BPs associated with REs due to BDAPs. Correlation and selection criteria between BPs and BDAPs are provided in Section III. Section IV presents the integrative framework and the primitives of the proposed approach to evolve REs. Principles of the framework to sustain characteristics of RE are depicted. Evaluation methodology to depict the indicative measure for evolving REs is illustrated in Section V with experimental BPs in 7 production deployment iterations. Finally, Section VI summarizes our findings and describes future and ongoing work.

II. Factoring Impacts of Digital Technologies to Big Data in Real-Time Enterprises

When architecting REs, organizations consider responsiveness of each BP to satisfy a specific objective [7]. Depending on identified scenario and corresponding action, the requirements in real-time environments may vary from a seconds to hours. It translate into the service level agreements (SLAs) of the enterprise. Real-time characteristics of an enterprise is generally envisioned as the ability for an organization to react to business needs and changing business circumstances within the established threshold of SLAs. REs are realizing that access to critical business information at the right time is crucial for maintaining competitive advantages in reactive behavior of the BPs.

However, the DTs are introducing new dimensions and fragmentation of information [1] across the enterprise and beyond complicates the diversification in reactivity of the BPs. Considering the smart city example of collaborating justice department with mobility data, without the availability of accurate location of the mobile device information, consistent and timely information of the changing policies information can't be delivered and rapidly on-board individual or business in terms of adhering to the changes in information-centric regulations.

To empower such dynamic environments, enterprises are striving to evolve by leveraging the power of new and relative information generated by the assets of the DTs including mobile, social collaboration, and application programming interfaces (APIs) through big data. During our research effort, we analyzed impact of upcoming DTs to traditional way of architecting and factoring REs to enable the extended enterprise using BDAP.

A. Primary Concerns of RE in Perseverance of Big Data and Our Analysis to Identify Impact of DTs

Despite recent development in big data to offer highly intelligent information value stream, there are gaps and adaptability challenges in providing real-time capabilities during the integration of information due to introduction of innovative DTs. It dictates an immediate requirement for correlating the responsive value and utility of big data in REs. Changes in regulatory compliance of web technologies, increased customer attrition, noticeable fluctuation in social platform activities, migrating buying patterns, and improvements to consumer facing BPs are the initiatives that depend on organizational adaptation of upcoming DTs and environment in order to succeed.

The challenge is to couple the management of the operations with the drivers of the business to emulate the characteristic of RE [7], [12], and [4]. It requires a shift in architecture that crosses the operational and business boundaries and provides a more holistic approach to managing and controlling the operation for BPs in big data ecosystem [6]. We identified preliminary reasons in either introducing or updating DTs. They are to gain in-depth understanding of the contextual information [13] and need of operational granularity [14]. Understanding that optimization for adaptability within the contextual information of each participant in big data ecosystem is more important than optimizing for cost, performance, or features. RE needs to accept change as a process, rather than as an event. It enables big data ecosystem's adaptability and evolving business models along with DTs' trends. Enterprise integration aspects, big data function integration, operational self-sufficiencies, are the three key ingredients. The analysis indicates that big data requires exact context to be able to build associative aspects of the BPs and corresponding operations.

We derived an approach to encapsulate these contextual information of participants into the BPs based on the factorization to evolve BDAPs with the advancements in DTs. Participants are considered any system or subsystem (example: database, file system, etc.), software, interface, component, infrastructure element, network, device, and third-party or hosted solution participates in formation of a big data ecosystem. Each participant utilizes different set of big data contextual information depending on the goals and nature associated with the particular operation of BP. The most prominent example is the automated payment that is usually paid and managed by the vendor or receiver. It needs the information about the payer and the method of payment. However, the context of payment differs when it is paid by credit card versus when it is paid with PayPal. The scenario indicates that, for the same purpose, when different vendors are utilized, they need diversification and monitory information specific to DTs associated with it.

B. Architecture of REs in Big Data Ecosystem

Due to scattered approaches of adapting DTs and absolutely no standardization when introducing novel DT platform, REs are bound to introduce and streamline custom RE architecture and respective BPs. Typically, they are placed in logically categorized, either in layers, components, objects, services, or agents. Based on our analysis and investigation of various different RE initiatives [6], [7], [12], and [15], we identified that there is a common theme behind placing the conceptual classifications. It is based on the day-to-day practicality of REs and ongoing challenges. Following are the objective of the RE architecture across diversified industry segments in presence of big data technologies.

- Standardization across multiple technologies, vendors, partners, and internal as well as external communication channels.
- Association with short and long term goals of the business in association with big data.
- Cohesive and flexible to accommodating all level of changes and evolutions of underlying participants.

- Manage, monitor, and support operational execution of the big data ecosystem.
- Automate and modernize existing systems in adherence to the BPs.

The "R-words" - responsiveness, relationship, reasonability, refinability, and resiliency are the five key conceptual classification for each of the logical category defined to formulate the RE and achieve big data's functional objectives. The real question is, how this classifications are impacted due to the introduction of or evolution in digital environment? In following subsection we describe each classification category and factors associated with them to foresee the level of impact.

C. Factors Impacting Big Data in Presence of Information Generated by DTs

As indicated in Fig. 1, we have placed primary conceptual classifications of architecting RE and identified factors impacting each of the classification due to continuous information generated by DTs. The REs are driven by BPs and the corresponding operations. Any new introduction of the information associated with DTs that needs to be introduced has to be analyzed in the perception and input from the BP specification and rationale [2] between the contextual information and BP activity. We have primarily considered BPs, BP activities, functionalities of each participants, operations associated with participants, and contextual information of DTs to participant for identifying the impact factors that are generic enough to recognize from any RE architecture.

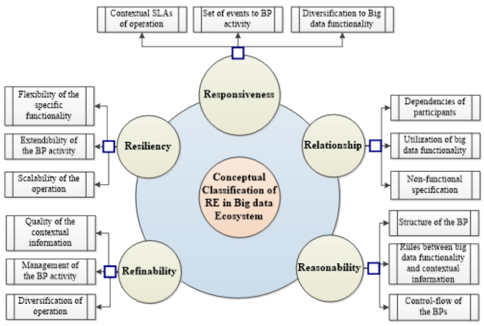

Fig. 1. Conceptual classification to formulate the RE in big data ecosystem and factoring impacts.

Following are the brief understanding of each classification and correspondingly identified impact factors.

1) Responsiveness

It is articulating an ability of enterprise to respond based on the granular specification of the business scenario. Typically, organizations place precisely identified BP activities to accomplish responsiveness. Event driven architecture is also utilized in many cases to achieve responsiveness. The factors that impacts the responsiveness are described below.

- Contextual SLAs of the specific operation placed
- Set of events, event level granularity, and condition to trigger specific BP activity
- Logical diversification necessary to specific functionality

2) Relationship

RE architecture establishes logical services to define the relationship among and across different participants of big data ecosystem. Traditionally, the relationships are placed within the context of databases or data sets. However, with the advancements in service oriented architecture (SOA), it is possible to define and change relationship at runtime. Following are the primary factors impacting the relationship.

- Dependencies among the different type of participants
- Utilization of specific functionality offered by the participant
- Non-functional specification between the participants such as security, monitoring, logging, and auditing

3) Reasonability

Providing appropriate decision based on logical conclusion either as a result of certain specific condition is the anticipated characteristic of RE architecture. As a matter of fact, many enterprises instantiate negotiation process based on the outcome of such logical functionalities in RE. The factors that fall into this classification are listed below.

- Structure of the BP, BP roles and responsibilities, and BP activities
- Rules associated between the specific functionality and contextual information
- Control-flow of the BPs defined for specific purpose in the RE

4) Refinability

RE has to be attuned for any newly identified context or even the condition of the system, platform, and infrastructure of big data ecosystem. Refinability classification is to improve and keep pace with the modernization across the line-of-businesses. The factors that are impacting the refinability are as follows.

- Quality of the big data contextual information to provide accurate understanding of operation
- Management of the specific BP activity in correlation with contextual information
- Diversification necessary to the specific operation of big data

5) Resiliency

Generally, it is in the form of granular operations logical components in scope of RE. The most prominent example is platform services running independently of BPs such that BPs can be executed irrespective of the platform. Factors impacting resiliency are given below.

- Flexibility of the specific big data functionality
- Extendibility of the BP activity along with evolution of big data ecosystem
- Scalability of the operation

The classifications presented in this section can be extended and also ca have sub level of classifications. The factors impacting to each classification are direct reflection of tremendous amount of information generated due to introduction of innovative DTs. Now, the most logical step is to identify how these factors contribute and needs to be considered when architecting RE for readiness with upcoming information generated by DTs.

III. POSITIONING BIG DATA ARCHITECTURE PATTERNS

Traditional architectural approached integrate runtime environment for data synchronization and information flow, without consideration for the factors impacting the RE architecture and supporting DTs across various integrated point solutions [10]. Consider a BP that touches a customer relationship management system built as client-server system, a supply-chain system built as Web based solution, social collaboration platform build using Yammer, and a sales commission system built in mainframe using COBOL to the mobile application.

BDAP provides standardize way to store, acquire, process, and analyze for recurring scenario [16] and [17] to integrate information generated from various sources including newly introduced or upgraded DTs. Every big data source can have different characteristics, including the frequency, volume, velocity, type, and veracity of the data. When big data is processed and stored, additional context can be introduced. Charting BDAPs and BPs of the RE presents a structured and pattern-based approach to simplify the task of integrating generated information from DTs at various stages of the RE architecture in consideration of the identified impact factors in Section II.

Many researchers and industry leaders facilitates custom building the BDAPs, however, minimal effort is to provide standard guideline for creating BDAPs. Also, the real perspective of BPs and RE are not considered. We identified sequential step to define BDAP based on the impact factor for specific context of the RE and associate BP to it. The steps are iterative and it needs to be performed after or during introduction or upgrade of DTs. Fig. 2. Provides the over view of the phases. The outcome is the correct level of mapping for BDAPs.

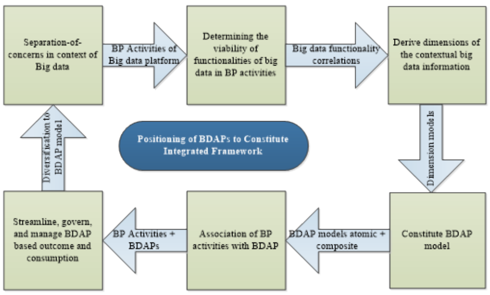

Fig. 2. Phases to position BDAPs.

A. Separation-of-Concerns in Context of Big Data

The initial step is to establish the context of big data in BPs. It is to correctly place the concerns based on methodology to process big data information generated from all the sources. Business requirements determine the appropriate processing methodology (Example: Predictive, analytical, ad-hoc query, and reporting). If same set of data needs different processing methodology in the context of BP then separate condition based BP activities can be leveraged. The consumer information and identified buying patterns can be utilized for marketing whereas it can be utilized for sending personalized discount coupons within the same BP, however, as separate BP activity.

B. Determining the Viability of Big Data Functionalities in BP Activities

The specification to model the BP activities with respective to the processing methodology for big data information are retrieved in this phase. The BP activities correlates the information necessary to perform the functionalities of the big data. For example, the configuration is available to send reminder to the specific mobile device. The information of the mobile device and the configuration are associated to approach the functionality of sending the notification.

C. Derive Dimensions of the Contextual Big Data Information

The association of information, processing methodology, and the big data functionalities forms the contextual information. The contextual information is dimensioned based on the data types, frequency, their utilization, and other aspects such as data format and size. Every big data pattern has its way to determine data types, typically data types are transactional, historical, master data, and others. The dimensions is also depend on the utilization. The utilization are generally associated with the role. The agent accessing the policy holder information whereas underwriting accessing the same information has different purpose and level of authorization. Similarly, during the definition of BDAP, the dimension needs to vary based on the frequency of their generation that will determine the right level of processing to imply. The dimensions can have sub level of dimensions and they can be extended.

D. Constitute BDAP Model

Dimensions are associated with the contextual information when modeling the BDAPs. The combination of dimension and operation of the RE determines the BDAP. The atomic BDAPs are modeled separately from the BP activities with the dimension and operation of RE as the paradigms. The example of the atomic BDAP is metadata transformation where transformation is the RE operation whereas metadata is based on the type of data processed and their utilization. If necessary, multiple atomic BDAPs can form the composite BDAP. One such example is metadata transformation can be combined with access pattern to access the specific type of metadata by the specific role.

E. Association of BPAactivities with BDAP

The next step is to associate the BDAP to the BP activities. The mapping between the BDAP and BP activities determines the behavior of the BPs and also introduce the necessary diversification required in various different scenarios of RE. Additional or diversification of BP activities is possible by leveraging different BDAPs. The most prominent example is storage pattern for cloud environment can store the data whereas analytics pattern will provide analysis information.

F. Streamline, Govern, and Manage BDAP Based Outcome and Consumption

The outcome of the BPs is consumed by various users within the big data ecosystem and by entities external to it, such as consumers, vendors, partners, and suppliers. Detecting security breach by intercepting transactions in real time and protecting privacy of consumer immediately with corrective action is an example. It mandates to enforce and streamline policies consistently across big data ecosystem. The SLAs associated with BPs in association of

BDAP are managed and appropriate notifications are raised in this step. Automated steps can be launched to trigger specific BP activity based on the associated BDAP, for example, the BP activity to block the use of a credit card can be triggered if suspicious event found based on the BDAP analytics pattern. Primarily, the assessment to evaluate whether diversifications pertaining to functions or operations of RE is necessary due to DTs during the subsequent iteration to evolve RE.

When all the phases to position BDAPs are correctly being implied, it provides consistent approach to generate contextual information and BDAPs for the upcoming information due to introduction or upgrades of the DTs. It is leveraged to construct an integrative framework for execution and quantifying the evolution of RE.

IV. An Integrated Framework of Real-Time Enterprise

To provide the true characteristics of any RE, it is necessary for each and every participant and its associated functions, operations, or BDAPs should enable one of more BPs. If any participant generating ad-hoc activity that is not associated with and contribute to BPs then RE architecture is not complete. With this recognition, we have defined initial types of BPs based on the behavior of corresponding BP activities to constitute the open-ended integrated framework. Fig. 3 illustrates the preliminary types of processes based on association of BDAPs during the establishment of integrated framework for RE. Further, this section describes the significance of each type and principles to sustain the characteristics of RE during the advancement of DTs.

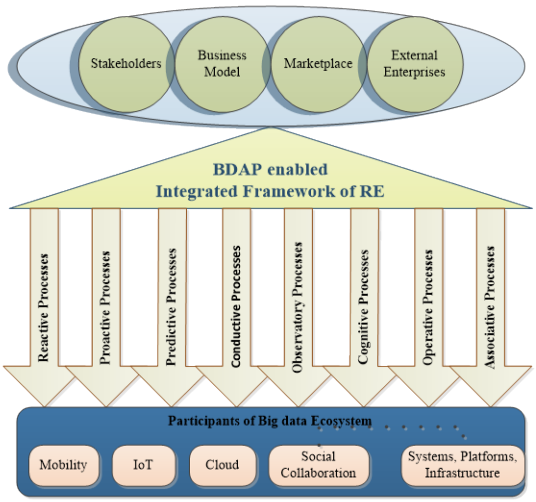

Fig. 3. Preliminary types of processes based on association of BDAPs to contitute open-ended integrated framework for RE.

A. Types of Processes to Constitute Integrated Framework

BPs of REs are associated with one or more types of processes within the integrated framework considering their complexities and number of BP activities that forms the BP. However, each BP activity needs to be uniquely depict the behavior due to which BP has been placed to the particular type. Following is the brief of each integrated framework BDAP process type (**IFPT**) with example of a BP activity. Additional types can be introduced depending on the progression or RE in presence of DTs.

Reactive processes (RTP): BPs with the activity that respond to the propagation of change at runtime in BDAP are categorized as RTP. Car manufacturer's factory automation where moving from one stage of assembly to another needs to react based on the specific intermediate qualitative conditions of the stage completed is RTP.

Proactive processes (PRP): PRP is the set of BPs that deals with the expected occurrence of the activities and defines the control to them for associated BDAP. Runtime policy management and invocation for the human resource department is an example of PRP.

Predictive processes (PDP): The BP activities that needs to be carried out for providing the predictive results within the workflow based of factual information in BDAP. Hourly weather prediction is an example of PDP.

Conductive processes (COP): COP is to perform specific task that are invoked to complete the sequence utilizing BDAP. The billing to the customer is an example activity of COP.

Observatory processes (OBP): The BP activities that are created to observe specific situation is classified as OBP. Monitoring sale of particular product falls in the category of OBP.

Cognitive processes (CGP): The BP that can mature BDAP by acquiring information and setting conditions based on the paradigms defined to gain appropriate result can be placed under CGP. Providing discount based on historical purchasing or loyalty points of particular consumer is an activity of CGP.

Operative processes (OPP): When BP needs to operate based on certain prior conditions of BDAP to produce the define set of outcome then it is OPP. Automated dental treatment based on the previously established automated procedure from BDAP is an example of OPP.

Associative processes (ASP): ASPs are generally those BPs that associates BP activities with roles and responsibilities identified within BDAP. Manager role differs from employee, however, during the annual appraisal and assessment activities, they both are required to follow certain steps in co-ordination.

B. Principle to Sustain Characteristics of RE

Due to increasing dependencies of digitization in businesses and generated information, the way of defining and performing big data functions, operations, and contextual information are required to continuously adhere to the DTs. When implying integrated framework, requirements of digitization is introduced either with new BP activities or diversifications to BP and BP activities based on the dynamics between participants of big data ecosystem and associated contextual information (example: offering 20% discount for 2 hours for online purchase of a particular product). They are temporal in nature, however, can occur in future with different BDAPs' attribution. It is necessary to define and monitor principles to sustain the characteristics of BDAP. Following are the preliminary principles and purposes to diversify BPs for iteratively evolving BDAP.

- Scoping and profiling of the big data functionalities during requirements of DTs to generate and place accurate contextual information.
- Gradually evolve and imply operational governance in the diversity of the BPs based on BDAP from formulation to execution in presence of DTs.
- Precise BDAP modeling to place existing dimensions, paradigms to define them, and their utilization across RE are necessary before introducing new dimension. Continuous assessment is necessary to redefine and update existing dimensions.
- Consistently evaluate, place, and rationalize relationship between BDAPs and BP activities when advancing integrated framework due to new scenarios of DTs.
- Accurate correlation between BP activities and their purpose to correctly recognize appropriate IFPT is necessary before allocating them or introducing additional IFPT. Consequently, utilization of IFPTs need to be consistent across big data ecosystem before decision to diversify them.
- Specify impact factor for participants in diversification of BDAP associated with BP activities and streamline OBPs associated with them across big data ecosystem.

V. Evaluate and Evolve Real-Time Enterprises

The conceptual classification based IFPT and principles derived for RE integrated framework is implied and analyzed during the integration of manufacturing production processes with corresponding supply-chain in presence of Internet-of-Things (IoT). The analysis and deployment iterations to include gradual advancements in IoT capabilities are performed over existing 42 BPs and 223 BP activities. The phases to associate BDAPs with BP activities are completed in each iteration of the deployment. BP activities upgraded and introduced based on the necessary IoT functionalities required to be established. In this section, we are presenting an approach to evaluate the measure of each iteration that provides indicative evolution of RE when advancing for DTs in terms of Degree of Coverage (DoC) for each identified IFPT.

Severity levels (SLs) are assigned to each diversification introduced to or new function and operation of RE due to DTs. Although, big data ecosystem can define their levels and interpretation of severity levels, we have defined 5 levels of severity as described below.

SL1 (Critical): If diversification in big data function or operation is anticipated to be critical and interrupts continuity in day-to-day business then it is categorized in ISL1.

SL2 (Major): If one or more failures is expected due to requirements of DTs to big data function or operation then it is considered ISL2.

SL3 (Intermediate): When big data function or operation estimated to violate one or more specified SLAs then it is ISL3.

SL4 (Minor): If there is an anticipation of request for an additional feature or add-on capability in terms of DT.

SL5 (negligible): If certain extension is expected to be included for monitory aspect of big data function or operation then it falls in ISL5.

The assigned finite values for the severity levels (SLV) are SLV1 = 10, SLV2 = 8, SLV3 = 6, SLV4 = 4, and SLV5 = 2 corresponding to level listed above to quantify the diversification in RE due to DTs. Severity level allocation to specific RE function in consideration or upgrade or to be introduced is independent of the operations of RE. Vice versa, severity level allocation to specific RE operation in consideration or upgrade or to be introduced is independent of the functions of RE.

Equation 1 provides the formulae to compute the average weighing of the changes (diversification or new) to operations pertaining to all the BP activities of IFPT in consideration. #DOP represents the number of operations that needs to be either diversified or updated.

$$\mathrm{AWOP} < IFPT > = \frac{\sum_{j=1}^{\#DOP} [SLV_{<\mathrm{j}>}]}{\#DOP} \qquad (1)$$

Equation 2 provides the formulae to compute the average weighing of the changes (diversification or new) to RE functions pertaining to all BP activities of IFPT in considerations. #DFN represents the number of functions that needs to be either diversified or updated.

$$\mathrm{AWFN} < IFPT > = \frac{\sum_{i=1}^{\#DFN} [SLV_{<\mathrm{i}>}]}{\#DFN} \qquad (2)$$

The DoC pertaining to specific category of scenarios (DoC<IFPT><ITERATION (#)>) is identified in (3) during each production deployment iteration. It also provides indicative number for the relative coverage from previous iterations and whether the further diversification can be anticipated. The degree of coverage depends on the diversification in functions of RE, number of impacted operations, introduction of the dimensions, and number of BP activities associated with BDAPs.

In (3), DoC<IFPT><ITERATION (N)> represents DoC for specific IFPT in present iteration (that is, N is 7 for iteration number 7). Essentially, each iteration has dependency to the previous iteration of updates and diversification. DoC<IFPT><ITERATION (N-1)> represents DoC computed in the previous iteration.

$$\mathrm{DoC}_{<\mathrm{IFPT}><Iteration(N)>} = DoC_{<\mathrm{IFPT}><Iteration(N-1)>} + \left[\frac{\begin{pmatrix}(\#BDPA\_BPA/\#BPA)+\\(\#DOP/\#OP)+(\#DFN/\#FN)+\\(\#DDM/\#DM)\end{pmatrix}_{<IFPT>} \times 10^{P-2}}{P}\right] \qquad (3)$$

#FN represents total number of RE functions participates into the BP activities of IFPT in consideration, whereas #DFN is the number of diversified or newly introduced functions. #OP represents total number of RE operations participates into the BP activities of IFPT in consideration, whereas #DOP is the number of diversified or newly introduced operations. #DM represents total number of dimension models participates into the correlation between BDAP and BP activities of IFPT in consideration, whereas

#DDM is the number of diversified or newly introduced dimension models of IFPT. #BPA is the total number of BP activities participate to qualify corresponding BP to be in IFPT, whereas #BDAP_BPA is the number of BP activities diversified to or newly associated or introduced to BDAP. "P" indicates the number of paradigms considered to evaluate evolution or RE in presence of DTs (4, that is, #BPA, #FN, #OP, and #DM).

TABLE I represents the data for iteration 7 of the IFPT and associated BP activities.

TABLE I: DoC COMPUTATION IN ITERATION 7

IFPT	RE Paradigms in Presence of DTs							
	#BDAP_BPA (#BP	***AWFN***	***#DFN (#FN)***	***AWOP***	***#DOP (#OP)***	***#DDM (#DM)***	***DoC (N-1)***	**DoC (N)**
RTP	10 (55)	6	18 (115)	3	6 (68)	3 (18)	242.2	280.85
PRP	4 (42)	4	5 (76)	2	1 (62)	1 (12)	178.32	190.16
PDP	8 (35)	2	14 (52)	2	7 (23)	4 (23)	211.77	250.5
COP	2 (28)	6.5	2 (34)	0	0 (23)	0 (6)	169.42	180.76
OBP	3 (25)	2	3 (38)	0	0 (12)	0 (19)	153.61	160.55
CGP	5 (21)	4.5	5 (38)	2	1 (35)	2 (10)	188.1	215.28
OPP	1 (45)	7	2 (98)	4	2 (82)	0 (25)	223.01	229.57
ASP	4 (26)	4	6 (62)	2	1 (15)	0 (12)	188.35	205.2
Average DoC of RE							**194.35**	**214.11**

Fig. 4 illustrates the progress of RE and evolution of each identified IFPT from iteration 1 through iteration 7.

It is apparent from the presented analysis in Fig. 4 that each IFPT has different pace of gaining momentum when introducing DTs to existing BP activities. However, overall DoC receives steadiness during the progress from iteration to iteration. RTPs and PDPs requirements are more visible and recognized as we correlate BP activities and BDAPs during the subsequent deployments. The ASPs and CGPs are progressing in pace with other IFTP, whereas PRPs, COPs, OBPs, and OPPs remains steady in later stages after first few iterations. The DoC for each IFTP also reveals the trends of DTs and provides indicative optimization opportunity for RE as well as statistical direction to evolve in marketplace.

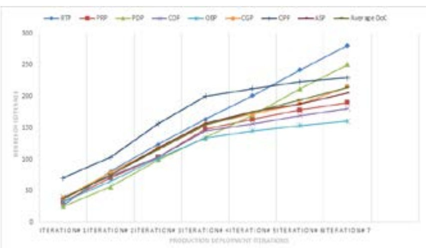

Fig. 4. Statistical measures of DoC during iterations 1 to 7.

VI. CONCLUSION

Even though many methodologies and architecture approaches of RE are defined, developed, and deployed during past decade, intense analysis indicates that businesses are encountering multifaceted challenges and complexities to evolve in presence of DTs and big data. The primary contribution of the research paper presented here is twofold. First is to position BDAPs for associating continuously generated information by upcoming DTs with BP activities. Another one is to provide BDAP enabled integrated framework for REs that can sustain the characteristics of REs in advancements of DTs and big data. It provisions desire diversifications necessary for a RE to enable multiple dimensions in the context of daily information generated by DTs such as mobile applications, social collaboration platform, and online browsing history. The paper consequently provides phases to derive and associate BDAPs in RE based on recognized factors impacting the characteristics of RE.

There are different types of BPs and each depends on functional and operational expectations of associated BP activities. The perseverance of BP activities are coupled with BDAPs to accurately relate contextual information provided by the DTs with BPs of a RE. The integrated framework assists RE by investigating the effects of DTs' interventions to efficiently diversify RE to achieve the requirements of digitization. It industrializes the BDAPs and evolves the RE based on rational problem solving to manage information generated by utilization of DTs. Further research is to develop optimization technique based on the indicative DoC of each IFPT. Many REs envision contextual information and their dimensions as an organizational asset. As REs mature in their decision-making processes, the governance of contextual information becomes more critical. We are progressing to derive operational governance for such big data contextual information and their dimensions.

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Vikas S. Shah received the M.S. degree in computer science from Worcester Polytechnic Institute, MA, USA in 1998 and the bachelor of engineering in computer engineering from Conceicao Rodrigues College of Engineering, University of Mumbai, India. Currently, he is chief architect in Connected Enterprise Services (CES) group at wipro technologies, NJ, USA. He has published 22+ papers in digital technology architecture, real-time enterprises, architecture methodologies, and integration approaches.

He headed multiple enterprise architecture initiatives and research ranging from startups, global organization, to consulting firms. Besides software architecture research and initiatives, he is extensively supporting pre-sales solutions, risk management methodologies, cloud strategy assessment, IoT implementation, and big data product selection.

Mr. Vikas Shah is member of International Association of Computer Science and Information Technology (IACSIT), Institute of Electrical and Electronics Engineers (IEEE), International Economics Development Research Center (IEDRC), Institute for Systems and Technologies of Information, Control and Communication (INSTICC), and European Alliance for Innovation (EAI).