A method for effective use of enterprise modelling techniques in complex dynamic decision making

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Abstract. Effective organisational decision-making requires information pertaining to various organisational aspects, precise analysis capabilities, and a systematic method to capture and interpret the required information. The existing Enterprise Modelling (EM) and actor technologies together seem suitable for the specification and analysis needs of decision making. However, in absence of a method to capture required information and perform analyses, the decision-making remains a complex endeavour. This paper presents a method that captures required information in the form of models and performs what-if calculations in a systematic manner.

Keywords: enterprise decision making; method; bottom-up simulation

1 Introduction

Modern organisations try to meet their goals by adopting appropriate courses of action. Evaluation of alternative courses of action and deciding best amongst them call for precise understanding of organisational aspects such as goals, organisational structure, operational processes and the past data [6]. The dynamic organisational structure, socio-technical aspects and emergent behaviour contribute to making it a complex dynamic decision making (CDDM) endeavour [12].

An effective CDDM hinges on the availability of: (i) the information required for decision-making in a structured and machine-interpretable form, (ii) suitable machineries to interpret the information, and (iii) a method to help identify the relevant information, capture it in model form, and perform *what-if* analyses. The current practice of organisational decision-making that relies heavily on human experts making use of the primitive tools such as spreadsheets, word processors, and diagram editors *etc.* fares poorly on all the three criteria mentioned above [12].

The existing Enterprise Modelling (EM) techniques and technologies, such as Zachman Framework [19], ArchiMate [9], i* [18], BPMN [17], System Dynamics (SD) [13], and Multi-Perspective Enterprise Modeling (MEMO) [7], help to capture information of interest and perform rigorous analyses. Similarly, the actor technologies, such as Scala Actors [8] and Akka [2], help specify and analyse the system with autonomous, adaptive and emergent behaviours.

Essentially, the EM technologies and actor technologies together support two of the three requirements of CDDM: (i) the ability to capture relevant information in a structured and machine interpretable form and (ii) the ability to perform required analyses. However, to the best of our knowledge, there is no work reported on how to address the third requirement of a method for CDDM.

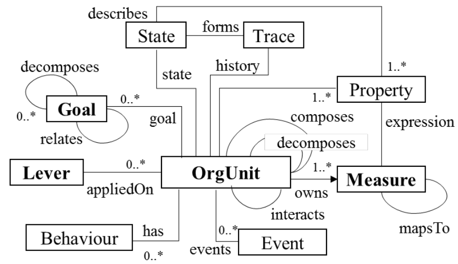


Fig. 1. Schema of an organisation

This paper presents a method that helps systematically represent the necessary aspects of an organisation in terms of suitable models, and perform simulation-based analyses leading to effective CDDM. The proposed method refines the management view of decision-making advocated by Richard Daft [6] (described in section 2), and the model construction and validation method advocated by Robert Sargent [15] (described in section 3). An illustration of the proposed method on a representative sample from real life is presented in section 4. Section 5 provides a summary and outlines further research plans.

2 Background and Requirements of CDDM

The management view of organisational decision-making [6] (henceforth referred as *Management Decision Cycle*) recommends an iterative process flow involving six process steps namely, *Recognition of Decision Requirement* [D1], *Diagnosis and Analysis of Causes* [D2], *Development of Alternatives* [D3], *Selection of Desired Alternative* [D4], *Implementation of Chosen Alternative* [D5], and *Evaluation and Feedback* [D6]. The process steps D1-D4 among them are arguably critical for CDDM as the cost and effort of implementing an alternative in D5 are often prohibitively high for most of the modern organisations. Moreover, an inappropriate selection of alternative in D4 may reduce the options in subsequent iterations of Management Decision Cycles.

The selection of best possible alternative in process step D4 requires precise understanding of Organisational *Goal*, *Structure*, *Behaviour*, *State* and *Trace* (or historical information) [3]. We represent these aspects using a unified abstraction of *OrgUnit* as shown in Fig. 1. Essentially, an OrgUnit contains the structural aspect through *composes*, *decomposes* and *interacts* relationships. It contains a set of *Goals* that represent the objectives of the OrgUnit, *Behaviour* that helps in achieving Goals, a set of *Measures* that describe key performance indicators, and a set of *Levers* that describe possible courses of action.

In this formulation, the *Organisation* is a specialised OrgUnit that composes multiple [de]composable OrgUnits along multiple levels; the Organisational Goals flow from bottom-to-top along Organisational structure; the Organisational behaviour exhibits compositional and emergent characteristics; and the Measures are typically localised and they flow from bottom-to-top along goal decomposition structure.

Therefore, organizing the relevant information for CDDM faces several fundamental dichotomies such as top-down/bottom-up [16], composional/decompositional, and

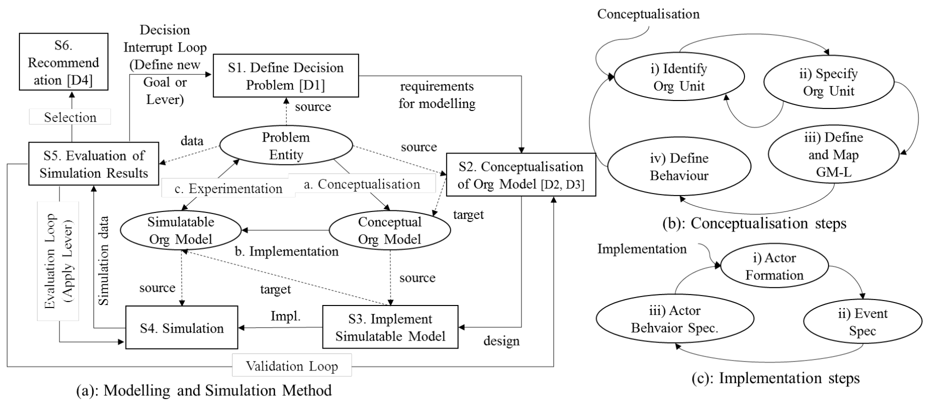


Fig. 2. Overview of modelling and simulation method

localized/globalized. In addition, the analysis techniques need to be cognizant of reductionist/emergentism principles [4].

The existing enterprise modeling and actor technologies are cognizant of these dichotomies at a varying degree. For example, the goal specification languages such as i* [18] advocate a top-down method for goal modelling. The EM languages, such as ArchiMate [9], MEMO [7] and 4EM [14], advocate a top-down method, decomposition abstraction, and globalized view of the system to represent the Goal, Structure and Behaviour of organisation in an integrated manner. The BPMN [17] and SD model [13] predominantly support top-down specification and analysis approach. On the other hand, actor languages and frameworks [8, 2] advocate localised view, bottom-up approach, composition and emergentism. While the technologies have provision for the required primitives for CDDM, a means for a seamless integrated use of the technologies is missing. This lacuna is further aggravated by conflicts in promoting a top-down reductionist approaches such as in DESIRE (DEsign Specification of Interacting REasoning components) [11] and bottom-up approaches such as that advocated by Kinny et al. using Belief-Desire-Intention (BDI) paradigm [10].

Principally, none is capable of combining top-down/bottom-up design principle, reductionist/emergentism analysis techniques, composional/decompositional abstractions, and localized/globalized perspectives as desired. They are also found wanting in terms of ensuring model validity and correlating with the management view of decision-making. The next section describes our proposed method.

3 Approach

We conceptualise an iterative method to construct a reliable and simulatable models of organisation and conduct required *what-if* analyses in a systematic manner. The proposed method contains six method steps namely *Define Decision Problem* [S1], *Conceptualisation of Organisation Model* [S2], *Implement Simulatable Model* [S3], *Simulation* [S4], *Evaluation of Simulation Results* [S5], and *Recommendation* [S6] as shown in Fig. 2 (a). Principally, these steps implement the modelling and validation method proposed by Robert Sargent in [15] (henceforth referred as M&V Method) to realise the decision steps D1-D4 of Management Decision Cycle. The proposed method uses three representations namely *problem entity*, *conceptual model*, *computerized model* to transform a problem entity (*i.e.*, description of real organisation) into an analysable model as advocated in M&V Method. Proposed method also adopts the operational validity technique described in M&V Method to establish veracity of constructed models for what-if analyses.

3.1 Method Definition

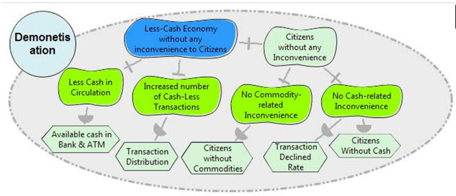
The detailed activities of six method steps of Fig. 2 (a) are illustrated below:
Define Decision Problem [S1]: The method step *Define Decision Problem* formalises decision problem and defines the scope for *what-if* scenario playing by identifying the *Goals*, *Measures* and *Levers* from problem entity.

The process step S1 uses three sub-steps namely *Goal Definition*, *Measure Identification* and *Lever Identification*. These sub-steps allow for identifying and specifying: a top-down goal decomposition; Measures for all leaf goals of the constructed goal model; and the set of Levers that may impact identified Measures. The i* notation is used as a methodological device for these concepts [18] (*see* Fig. 3 (a)). The Lever set is augmented by a decision table comprising a cross-tabulation of Levers and Measures as shown in Fig. 3 (b).
Conceptualisation of Organisation Model [S2]: This step defines a logical model of an organisation for determining the domain information relevant to a specific decision making problem.

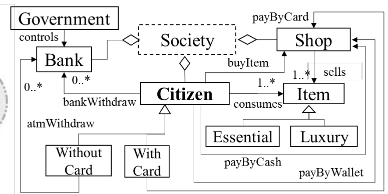
We use a four-step iterative process to construct Conceptual Organisation model from problem entity specification. The process steps are: (i) Identify Org Units, (ii) Specify Org Unit, (iii) Define and Map GM-L, and (iv) Specify Behaviour as shown in Fig. 2 (b). Process step *Identify Org Units* identifies prospective OrgUnits such as organisation, organisational units, sub-units, stakeholders, resources from problem entity.

Together, these two process steps provide representational capability for describing states and trace information; interacting Events; compositional relationships; interactions between OrgUnits. The process steps also allow for refining of Goals, Measues and Levers as well as defining micro-behaviour of OrgUnits.

The ordering of the process steps allow for both a top-down decompositional approach starting from specification of an OrgUnit and a middle-out approach that uses behaviours to specify details of other OrgUnits. As well as using i* model to specify Goals and Measures, an extended form of class diagram to represent OrgUnits and the their structure, and a form of state machine to depict behaviours.
Implement Simulation Model [S3]: This method step converts a Conceptual Organisation model into machine interpretable specification, which we term as Simultable Organisation Model as shown in Fig. 2 (a). We use the notion of *actor* [1] and an extended actor language ESL [5] to represent a machine interpretable organisation specification. A three step process (as shown in Fig. 2 (c)), for example, maps OrgUnits into an actor specification and interactions between OrgUnits into event specifications. The full mapping is shown in the example in Section 4.
Simulation [S4]: We use an actor-based simulation (in particular ESL simulator [5]) to analyse what-if scenario formulated in method step S1. This step simulates the simulat-



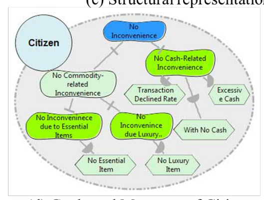
(a) Goals and Measures of Demonetisation



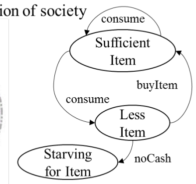
(c) Structural representation of society

Measures / Levers	Available Cash in Bank and ATM	Transaction Distribution	Transaction Declined Rate	Citizens Without Cash	Citizens without Commodities
Without Lever					
Motivate Citizen not to Hoard Cash					
Insentivise Alternate Payment					
Reduced Bank and ATM withdrawal limits					
Faster cash replenishment					

(b) Decision Table for Demonetisation



(d) Goals and Measures of Citizen



(e) Item consumption and buying Behaviour

Fig. 3. Produced Model Artefacts

able organisation model (with or without lever) and captures Measures from simulation results. Each simulation run captures a row of the decision table (as depicted in Fig. 3 (b)) formulated in method step S1.

Evaluation of Simulation Results [S5]: In this step, during the evaluation, a human expert interprets the simulation results and may continue exploration of the problem where operational validity is not satisfied. This may be done by adjustment of levers, selection of different levers or identification of new levers through iterative actions. (See Fig. 2 (a).).

Recommendation [S6]: This step recommends one or more Levers that can be implemented in real organisation.

3.2 Validation

Our method uses a validation loop that iterates over the method steps S2-S3-S4-S5 and compares simulation results with real or predicted data to establish operational validity [15] of constructed Conceptual Organisation model and Simulatable Organisation model. We consider operational graphics [15] of Trace and Measures as a basis for evaluation, and rely on human experts to certify the validity.

4 Illustration

On November 8, 2016, the Indian government pulled out 86.4% of the cash in circulation by derecognising two of the highest denominations currency notes - 500 rupee note and 1000 rupee note. The primary objective of demonetisation[1] was to reduce cash-based transactions that led to a shadow economy. This sudden and disruptive initiative resulted into prolonged cash shortages, financial crisis and inconvenience to the Indian population. The initiative was criticised for inadequate a-priori decision-making. This is a real life example of CDDM involving a socio-technical system with significant dynamism, uncertainty and emergentism. This section introduces the problem entity and illustrates how proposed method can be applied for a CDDM.

[1] https://en.wikipedia.org/wiki/2016_Indian_banknote_demonetisation

4.1 Problem Entity - Case Study Description

The *problem entity* discussed in this paper is a well-formed subset of demonetisation problem that focuses on bounded set of activities of common Indian citizens. In a normal situation, the citizens consume essential and/or luxury commodities (*e.g.*, food, medicines, *etc*.), and avail various services (*e.g.*, medical assistance, hospitality services, fitness related services, *etc*.). They buy commodities from shops/suppliers, avail services from service providers, and pay for their purchases and services. Citizens withdraw cash when cash-in-hand dips below a threshold value. A class of citizens may hold credit and/or debit cards and may choose to pay by cash or by card for a purchase, and may withdraw cash from ATM machine and/or bank. In contrast, a citizen without a card always pays by cash and withdraws cash from bank.

The normal behaviour of the key stakeholders were significantly disrupted by demonetisation initiative leading to a variety of adaptations such as banks enforcing enforcing set of restrictions on cash withdrawals to manage a fairer distribution of the introduction of new currency notes being introduced at a fixed rate - a mint-centric constraint. Shops adapted by accepting alternate payment options such as mobile wallet and card payment whenever they observed drops in sales. Individual citizens adapted by changing their payment patterns using mobile wallets and debit/credit cards to avoid using ATMs. Some citizens also resorted to temporary cash hoarding *i.e.*, withdrawing cash way in excess of their needs.

Given the above scope or problem entity description, the key objective of decision-making is to identify the set of appropriate *Levers* that can restore normalcy after demonetisation, *i.e.*, no notable denial of service from banks and ATM machines, no cash related inconvenience and no commodity related inconvenience to the citizens. The next subsections describes the execution of proposed method steps and their outcomes.

4.2 Define Decision Problem [S1]

The method starts with the Define Decision Problem [S1] step that produces goal models and decision tables. The problem entity described in subsection 4.1 aims for a high level Goal namely “Less-Cash Economy without any inconvenience to Citizens” as shown in Fig. 3 (a). Method step S1 decomposes the high-level Goal with three sub-Goals namely “Less Cash in Circulation”, “Increased number of Cash-Less Transactions”, and “Citizens without any Inconvenience”. The latter sub-Goal is further decomposed to two sub-sub-Goals namely “No Commodity-related Inconvenience” and “No Cash-related Inconvenience”.

The method step S1 identifies five Measures: “Available Cash in Bank and ATM”; “Transaction Distribution” (*i.e.*, distribution of cash, alternate payment or wallet, and Card payments); “Citizens without Commodities”; “Transaction Declined Rate”; and “Citizen without Cash” for leaf-level goals as shown in Fig. 3 (a). The method step S1 also identifies the possible Levers that may influence the Measures and therefore the Goals. The identified Levers are - “Motivate Citizen not to hoard Cash”, “Incentivise Alternate Payment”, “Reduce Bank and ATM Withdrawal Limit”, and “Faster Cash Replenishment”.

The decision formed using table using identified Levers and Measures is illustrated in Fig. 3 (b). The resultant structural, goal and measure, and state behaviour models from S2 form the basis for implementing a simulatable specification for decision-making related analysis.

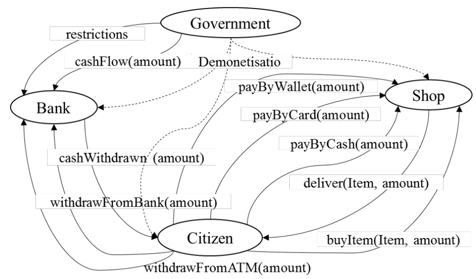


Fig. 4. Schema of simulatable model

4.3 Conceptualisation of Organisation Model [S2]

S2 and its sub-steps are used to construct the Conceptual Organisation Model from the problem entity description. Here, five key OrgUnits namely "Bank", "Shop", "Item", "Government", and "Citizen" are identified together with their structural relationships through an iterative process. The resultant artefact is depicted using a class diagram in Fig. 3 (c). Sub-steps are used to define the Goal and Measures of identified OrgUnits. Fig. 3 (d) depicts the Goal and Measures of Citizen OrgUnit. Finally the behaviour of Government, Shop, Bank, Citizen, and their specilised OrgUnits is defined. A depiction is shown using firmed line box in Fig. 3 (c). A part of citizen behaviour that describes the item consumption and buying behaviours of a citizen is illustrated using a state machines notation in Fig. 3 (e).

4.4 Implement Simulatable Model [S3]

In this step, the models generated from earlier steps are (manually) translated into a schema of an actor specification depicted in 4. Here, OrgUnits are translated into actors namely Government, Shop, Bank and Citizen; the interactions are translated as events; the behaviours (*i.e.*, state machines) are translated into actor behaviour; and the demonetisation is specified as an event of the Government actor.

We also configure ESL simulator to display Measures using appropriate graphics. We have chosen 8 graphics panels to represent and help understand Measures as shown in Fig. 5. The "Trace on Payment Transaction Distribution" chart represents the Trace of "Transaction Distribution" Measure where the card transactions are displayed in green, wallet transactions in blue, and cash transactions in red. (*i.e.*, Transaction Declined Rate Measure). The "Payment Distribution" pie chart shows distribution of Card (green), Wallet (blue) and Cash (red) payments (*i.e.*, Transaction Distribution Measure at a specific time).

The "Citizen with no Cash" and "Citizen with excess Cash" charts describe the financial condition of those citizens with cash concerns (No cash Measure) and those hoarding cash (Excessive Cash Measure). Similar charts depict measures related to essential Items.

4.5 Simulation and Evaluation of Simulation Results [S4, S5]

A demonetisation scenario is simulated by considering a Society having one Government, one Bank, 15 Shops and 1710 Citizen actors for 150 'Days' where the Demon-

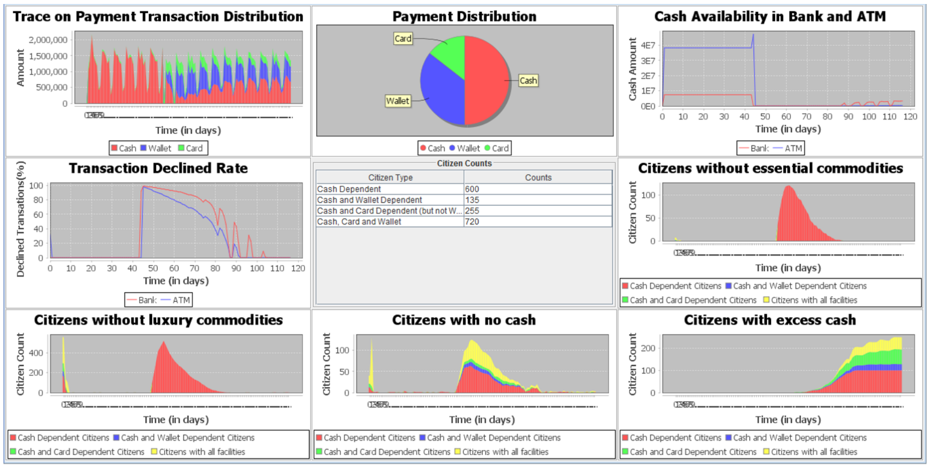


Fig. 5. Simulation Dashboard - Operational Graphics for Measures

etisation event is triggered at Day 45. A snapshot of simulation dashboard with graphs at the Day of 115 (*i.e.*, after 70 days of Demonetisation) is depicted in Fig. 5.

Overall, we observe the Measure values in pre-demonetisation phase (*i.e.*, before Demonetisation event) are stable and normal: (i) Banks and ATMs have enough cash to service Citizens without noticeable denial of service, and (ii) Citizens are not experiencing any deficiency for essential or luxury items.

The Demonetisation event is triggered at 'Day' 45 causing a sudden reduction of 86.4% cash from the Banks and Citizens. Subsequently, the withdrawals from bank and ATM decline whilst wallet payment and card payment increase significantly: the citizens have started facing a financial crisis and the citizens who are solely dependent on cash have started starving for essential and/or luxury items (as shown in Fig. 5). The adverse effects continue for 52 days and then the situation returns back to normal.

We capture simulation results in an extended form of the decision table formulated in method step S1 and shown in Fig. 3 (b). The extended table with simulation results is depicted in Table 1. Each row of Table 1 is the Measures captured by interpreting graphs of the simulation dashboard (refer Fig. 5) produced from a simulation run.

The observations of demonetisation specification without any Lever are captured in Row 1 of Table 1. The values of Row 1 of Table 1 signify that the Cash availability is low in post-demonetisation phase, the transactions distribution of Cash, Wallet and

Table 1. Consolidated Simulation Results

	Scenario	Cash Available in Bank and ATM	Transaction Distribution (After 100 Days)	Transaction Declined Rate	Cash Related Inconvenience		Commodity Related Inconvenience	
					Citizens without Cash	Citizens with excessive Cash	Citizen without essential commodities	Citizens without Luxury Commodities
1	Without Lever	Low	<50,42,8>	52 days	8.1%, 45	9.4%	7%, 41	26.3%, 42
2	Motivate Citizen not to Hoard Cash	Low	<50,43,7>	40 days	7%, 39	0	6.1%, 38	25.7%, 40
3	Insentivise Alternate Payment	Low	<35,57, 8>	45 days	7%, 31	9.4%	5.8%,34	25.7%, 35
4	Reduced Bank and ATM withdrawal limits	Low	<50,45,5>	48 days	5.8%, 46	9.4%	4.7%, 40	23.4%, 39
5	Faster cash replenishment	Low	<70,15,15>	18 days	5.4%, 17	0	3.2%,16	22%, 15

Card payments after 100 Days of Demonetisation are <50%, 42%, 8%> respectively, the bank and ATM transactions declined rate returns to normalcy after 52 Days, 8.1% citizens faced inconvenience due to cash, 7% citizens faced inconvenience due to essential items, and 26.3% citizens faced inconvenience due to luxury items.

4.6 Validation Loop

We observed simulation results of demonetisation specification without any Lever (*i.e.*, Row 1 of Table 1) and correlated with the information found in authentic press-releases and newspapers. The trends on cash conditions of different citizens, the inconvenience due to deficiency of essential items, and luxury items, and service of denial at Bank and ATM withdrawal are consistent with ground truths. In reality, the cash conditions in ATMs and Banks at the end of January 2017 (after 3 and half months of demonetisation) were just sufficient to serve their customers - this observation relate with the graph shown in “Cash Availability in Bank and ATM” graph of Fig. 5 . The alternative payment volume trend “Trace on Payment Transaction Distribution” chart (the value recorded in column “Transaction distribution” of Table 1) also matches with the Bloomberg report[2]. These observations and close correlations with reality ensure the operation validity of the constructed models.

4.7 Decision-making and Recommendation

After ensuring the operation validity of demonetisation models, we explored four Levers as described in decision table of Fig. 3 (b). Due to the space limitation, the simulation results of relevant simulation runs[3] are summarized using decision table in Table 1. A comparative analysis of rows 1-4 of Table 1 shows that the hoarding behaviour is one of the contributing factors for prolonged cash shortage - note row 2 is addressing the cash shortage issue in 40 Days, which is better than Row 1, 3 and 4. However, ATM and Bank withdrawal limits, as shown in row 4, are found as most critical to mitigate cash-less condition and deficiency of essential and luxury items (*i.e.*, citizen inconvenience).

A simulation run with faster cash-replenishment (five times more than standard cash replenishment rate) resulted into less cash shortage and less inconvenience to the citizens as compared to other alternatives as shown in Row 5 of Table 1. However, we found this option is not helping in moving toward a less-cash society as payment distribution of Cash, Wallet and Card payments is <70%, 15%, 15%> respectively.

5 Conclusion

This paper has contributed a method uses a top-down approach for defining goals, a middle-out approach for defining structural aspect of an organisation, and a bottom-up approach for behavioural specification, addresses methodical needs. The method incorporates best practice from both the simulation and management sciences disciplines.

[2] https://www.thequint.com/business/2017/02/17/demonetisation100daysindian-economy
[3] https://www.dropbox.com/s/q6xtz9el3sa6qzs/Demonetisation%20Experiment.pdf?dl=0

Critically, it addresses a significant gap in the methodology space for appropriate methods for supporting effective CDDM. While we have used specific techniques (such as i*, and ESL), our ongoing research suggests that several other alternative specifications can seamlessly be used in this method (such as Archimate and Akka). Our future research aims to to improve the agility of the proposed method by exploring human guided, semi-automated language transformations between the stages of problem entity specification through to simulatable models.

References

1. Agha, G.A.: Actors: A model of concurrent computation in distributed systems. Tech. rep., DTIC Document (1985)
2. Allen, J.: Effective akka. O'Reilly Media, Inc. (2013)
3. Barat, S., Kulkarni, V., Clark, T., Barn, B.: A model based realisation of actor model to conceptualise an aid for complex dynamic decision-making. In: 5th International Conference on Model-Driven Engineering and Software Development (2017)
4. Beckermann, A., Flohr, H., Kim, J.: Emergence or reduction?: Essays on the prospects of nonreductive physicalism. Walter de Gruyter (1992)
5. Clark, T., Kulkarni, V., Barat, S., Barn, B.: Esl: An actor-based platform for developing emergent behaviour organisation simulations. In: International Conference on Practical Applications of Agents and Multi-Agent Systems. pp. 311–315. Springer (2017)
6. Daft, R.: Organization theory and design. Nelson Education (2012)
7. Frank, U.: Multi-perspective enterprise modeling (memo) conceptual framework and modeling languages. In: 35th Annual Hawaii International Conference on System Sciences. pp. 1258–1267 (2002)
8. Haller, P., Odersky, M.: Scala actors: Unifying thread-based and event-based programming. Theoretical Computer Science 410(2), 202–220 (2009)
9. Iacob, M., Jonkers, D.H., Lankhorst, M., Proper, E., Quartel, D.D.: Archimate 2.0 specification: The open group. Van Haren Publishing (2012)
10. Kinny, D., Georgeff, M., Rao, A.: A methodology and modelling technique for systems of bdi agents. Agents breaking away pp. 56–71 (1996)
11. van Langevelde, I., Philipsen, A., Treur, J.: Formal specification of compositional architectures. In: 10th European conference on Artificial intelligence. pp. 272–276 (1992)
12. Locke, E.: Handbook of principles of organizational behavior: Indispensable knowledge for evidence-based management. John Wiley & Sons (2011)
13. Meadows, D.H., Wright, D.: Thinking in systems: A primer. Chelsea Green Publishing (2008)
14. Sandkuhl, K., Stirna, J., Persson, A., Wißotzki, M.: Enterprise modeling: tackling business challenges with the 4EM method. Springer (2014)
15. Sargent, R.G.: Verification and validation of simulation models. In: Proceedings of the 37th conference on Winter simulation. pp. 130–143. winter simulation conference (2005)
16. Thomas, M., McGarry, F.: Top-down vs. bottom-up process improvement. IEEE Software 11(4), 12–13 (1994)
17. White, S.A.: BPMN modeling and reference guide: understanding and using BPMN (2008)
18. Yu, E., Strohmaier, M., Deng, X.: Exploring intentional modeling and analysis for enterprise architecture. Enterprise Distributed Object Computing Conference Workshops (2006)
19. Zachman, J., et al.: A framework for information systems architecture. IBM systems journal 26(3), 276–292 (1987)