Intentional Linguistic Summaries for Collaborative Business Model Radars

Anna Wilbik, Rick Gilsing, Oktay Turetken, Baris Ozkan, Paul Grefen
Eindhoven University of Technology
Eindhoven, The Netherlands
{A.M.Wilbik, R.A.M.Gilsing,O.Turetken, B.Ozkan, P.W.P.J.Grefen}@tue.nl

***Abstract* —We propose the use of linguistic summarization concept to support business model design evaluation. In contrast to traditional linguistic summarization, we do not infer these linguistic summaries from data, but use their structure to express intentions or conditions for stakeholders to participate in the designed business model. Early phase business model design is highly uncertain, for which it is often difficult to quantify under what conditions the business model design would be acceptable for the stakeholders involved. Through generation of intentional linguistic summaries (ILS), stakeholders can make explicit under what conditions a certain business model design would be acceptable. Therefore ILS can allow a discussion on benefits and costs without focusing too much on details, which are rarely available in the early phases of business model design. These intentional linguistic summaries can consequently be used as soft KPIs to be validated once the business model is operational.**

Keywords—linguistic summaries, business model radars, protoforms, evaluation

I. Introduction

Business models describe the logic of how an organization creates value for the customer and how the organization in return benefits from this exchange [1]. Typically, business models are represented in textual or graphical forms [2] and make explicit the offerings an organization provides to its customers, the organizational activities it conducts to generate these offerings, the relationships or collaborations with partners needed and the operational or technical infrastructure deployed to support the business model [3]. Business models therefore can also be seen as a system of internal and external activities of organizations to create value for the stakeholders involved in these models [4].

Business models bridge the gap between business strategy (what an organization pursues in terms of strategic goals) and business process models (how the organization deploys and conducts its business activities) [5]. Therefore, to pursue strategic opportunities and to ensure that the internal organization supports these opportunities, the role of business models is pivotal. However, business models are not static: they are affected by both internal (organizational structure or resources) and external (market needs, competition) conditions that change over time and influence their lifecycle and competitiveness [6]. To remain competitive therefore, organizations should continuously redesign or innovate their business models [7].

Business model innovation is characterized as a process that features a set of iterative phases to guide the innovation of business models [8]. It encompasses steps such as the identification of strategic opportunities, the generation of novel business model design alternatives, analysis and selection of a viable business model design, and the operationalization of the selected business model design [9]. Accordingly, each step should be evaluated to support decision makers to continue business model innovation (and to advance to the next step) or to opt for redesign of the current draft business model. However, early phases of business model innovation are often characterized by higher degrees of uncertainty. Business data may be unavailable or based on many assumptions, as decisions with respect to concretizing the business model design and structure are made at later phases of the innovation process [10].

To support decision making in these early phases, qualitatively-oriented techniques are deemed appropriate that capture the preferences or knowledge of business model stakeholders. Techniques such as multi-criteria analysis, expert judgment or scenario analysis [10], [11] are techniques that may support decision making in these early phases. These techniques are often unstructured, however, or cannot properly be catered to the business model design or to the preferences or strategic goals of stakeholders with respect to the model. Purely qualitative techniques can leave many questions open with respect to the actual feasibility of a business model in business practice.

As a novel technique, linguistic summarizations can enable business model stakeholders to communicate 'lightly quantitative' preferences or requirements for draft business model designs to support decision making, without the need for high quality or accurate data. Through *soft quantified statements* or *intentional linguistic summaries* (ILSs) about elements of the business model design, stakeholders can express success conditions or key performance indicators (KPIs). These KPIs reflect whether the business model design is appropriate or whether the design should be changed. As such, it can provide support for early phase decision making in business model innovation. Moreover, as the ILSs are represented through generic protoforms, these statements can be further deepened through fuzzy membership functions and quantified as the business model innovation process progresses. Moreover the structure of an ILS is natural and intuitive and has been observed to be used by stakeholders, even before being introduced to them. This provides a comprehensive technique for business model evaluation in the context of business model innovation, which has not been presented before.

As a start to a more comprehensive approach, in this paper, we propose the generation of ILSs as KPIs that can be used to

978-1-7281-6932-3/20/$31.00 ©2020 IEEE

evaluate business model designs. We explain how the technique is used, and illustrate how intentional linguistic summaries have been derived for a practical case study.

The remainder of this paper is as follows. Section II provides further background on linguistic summaries, business model innovation and business model specification. Section III elaborates the proposed technique for generating intentional linguistic summaries. We illustrate its application in Section IV by means of a practical case study. In Section V, we provide an outlook of future research with respect to our approach. We summarize this paper in Section VI.

II. Background

A. *Linguistic summaries*

In this paper we consider linguistic summaries as proposed by Yager [12]. This approach was considerably advanced and implemented by Kacprzyk [13], Kacprzyk and Yager [14], Kacprzyk et al. [15-17]. This approach has also been applied to different types of data: numerical [18-20], time series [21-23], sensor data [24,25], texts [26], videos [27-29] and processes [30,31].

Linguistic data summaries are quantified propositions with two protoforms (or templates):

- simple protoform:

  Q y's are P;

  e.g., *most* cars are *new*

- extended protoform

  Q Ry's are P;

  e.g., *most new* cars are *fast*

where Q is the quantifier, P is the summarizer, and R is an optional qualifier. They are all modeled as fuzzy sets over appropriate domains.

The basic measure of the quality of the summary is the truth value, which describes the validity of the summary. Many methods for calculating the truth value have been proposed [32]. The truth value is not the only quality measure of a linguistic summary. An overview of different quality criteria can be found in [33].

B. *Business Model Innovation*

As organizations continuously have to adapt to changing customer and market requirements in order to remain competitive, the underlying business model(s) of an organization should be continuously innovated and redesigned [7]. Business model innovation is often characterized as an iterative process featuring sequential steps that describes how business models transition from idea conception towards implementation. A structural overview of the business model innovation process is proposed by [9], which identifies four sequential phases for business model innovation. The first phase, the *initiation phase*, describes the exploration of new ideas, opportunities or strategic challenges that drive new business model innovation and design. The next phase, the *ideation phase*, focuses on the design of a new or the adaptation of an existing business model and the motivation and inclusion of relevant stakeholder. The third phase, the *integration phase*, focuses on the concretization and quantification of the business model design. Lastly, the *implementation phase* focuses on the actual operationalization and implementation of the business model design.

Early phases of business model innovation are often characterized by significant uncertainty, as initial design decisions are more likely to change and the business model is only in draft form. As a result, 'hard' quantification of the business model design is often difficult. Therefore, qualitatively-oriented evaluation methods are preferred [10]. As the business model concretizes, data gradually becomes more available, allowing the use of quantitatively-oriented methods to support decision making [6].

C. *Specification of Business Models*

Several techniques for designing business models have been proposed, such as the Business Model Canvas [1], STOF model [34] and the Service-Dominant Business Model Radar (SDBM/R) [35]. Given that we focus on generating linguistic summarizations for all stakeholders represented in the business model design, we use the SDBM/R for the remainder of this work as this technique explicitly accommodates a networked representation of how value is created by partners in the business model design [37]. The SDBM/R has a circular layout (mimicking a 'radar') and features the value created for the customer (the *value-in-use*) at its center (see Figure 1). The template is divided into 'pie slices' which represent the actors that participate in the business model and contribute to value creation. Furthermore, the SDBM/R is composed of three rings that detail the *value propositions* (what value is proposed?)*, co-production activities* (what activities should be conducted to create the value?) and *actor costs and benefits* (what costs and benefits are generated as a result of participation by executing the activities?) of the actors in the business model, which

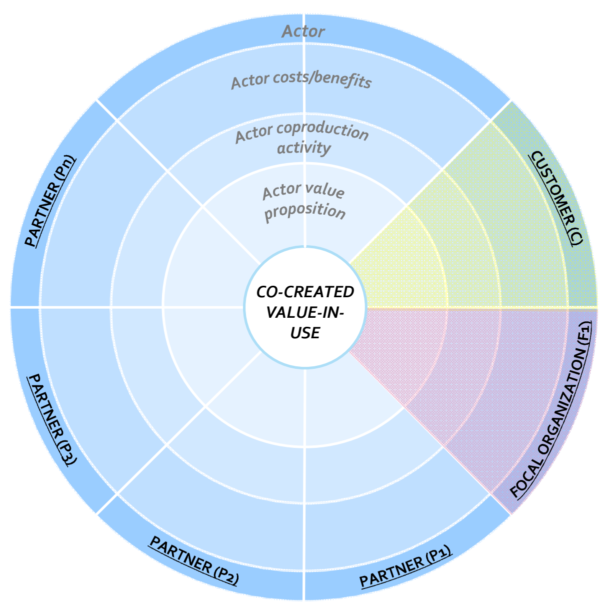

Figure 1: SDBM/R template for business model design [36]

intersect the actor pie slices. Accordingly, for each actor, their respective value proposition, co-production activity and costs and benefits can be modelled. Note that the customer is always considered as an active stakeholder in the SDBM/R approach.

The various elements in an SDBM/R radar are traditionally described in a qualitative way, but many of them can be further characterized by quantitative features to make the description more precise. We propose to use intentional linguistic summaries as a technique to 'softly' specify these quantitative features in early design phases.

III. Intentional Linguistic summaries

Intentional linguistic summaries (ILSs) are quantified statements with the same structure as linguistic summaries: *Q y's are P* and *Q Ry's are P*. The main difference is that ILSs are not created from the data, but capture intentions that the stakeholders want to be true. In other words, they specify desired constraints over future data.

For the SDBM/R technique we propose the following prototype set of ILSs:

- Intentional Linguistic Summary of the *value-in-use* related to the customer of the business model:

  Q customers have *Property of Value-in-Use*

  e.g., *almost all* customers have *received goods on time*

- Intentional Linguistic Summaries of the *benefits* for the customer expressing the desired benefits that occur often:

  Q customers have *Property of Benefit*

  e.g., *most* of the customers generate *little waste*

- Intentional Linguistic Summaries of the *costs* for the customer expressing the unacceptable costs that do not occur often:

  Q customers have *Property of Cost*

  e.g., *a few* customers have *some additional purchase costs*

- Intentional Linguistic Summaries over the *costs/benefits* for each (core) party expressing an acceptable cost/benefit ratio that occurs often:

  Q business operations for *(Core) Party* have *Property of Benefit/Cost*

  e.g., *most* transactions for *party X* have *a decent profit*.

  [Note that, it is also possible to create a meta-summary, like "*all* parties have *a decent profit on most transactions",* but this can make the model less flexible, if a change is required for one of the (core) parties.]

This is the initial set of ILSs based on our initial observations. The set will be verified and, if needed, extended, in future studies. The intentional linguistic summaries that are of these types are defined during the ideation phase of business model innovation, for which it is often difficult to explicitly quantify the conditions under which a business model design is viable (acceptable) per stakeholder. Each stakeholder generates a set of ILSs that capture the strategic goals or intentions of the stakeholder with respect to the business model. The generated ILSs therefore serve as soft quantified conditions or KPIs which motivate business model participation per stakeholder. Consequently, once an initial business model design is generated, the ILSs can be compared amongst stakeholders or domain experts who can judge whether these intentional linguistic summaries are acceptable and achievable.

If the model is judged to be valid for all stakeholders, the business model design progresses to the next phase (integration), in which the design is further concretized and quantified. With respect to intentional linguistic summarization, the precise membership functions of the used properties (linguistic values) are defined in this phase. Again, the now more detailed ILSs are used to evaluate whether the design is still achievable and acceptable.

In the implementation phase, the business model design is operationalized and implemented. With respect to ILS, data should be collected such that the truth of linguistic summaries corresponding to ILSs can be calculated. Therefore, in this phase, the ILSs are quantified such that it becomes apparent if the initial ILSs (generated in the ideation phase) still hold and that relevant data can be generated. In case this does not hold, changes have to be made to either the ILSs per stakeholder (such that the ILSs hold with respect to the quantified performance) or the business model design should be altered (which requires the process to transition back to the ideation or integration phase).

Lastly, once the business model is operational, the true performance of the business model can be measured. The resulting performance can consequently be contrasted to the initially derived ILSs, and to verify and monitor whether the performance of the operational business model adheres to the initial intent for innovating the business model.

Through generating intentional linguistic summaries at the start of the business model innovation process, stakeholders are enforced to explicitly specify the conditions under which they are willing to participate in the business model design (in soft quantified terms). As the viability of the business model design depends on the participation of all stakeholders, the summaries provide stakeholders with a well-structured and interpretable way of deriving KPIs, which can be used to evaluate whether the business model design is acceptable. Moreover, the ILSs are re-evaluated and further quantified at every design phase, such that a comprehensive approach to business model evaluation is established.

IV. Example of generation of ILS

As part of the start of our approach, we demonstrate the generation of intentional linguistic summarizations for business model evaluation (which happens in the ideation phase) by means of a real-life case study. The case study features a business model design that emerged from a practical workshop in the mobility domain (Figure 2). The business model design was generated as a solution to address and decrease traffic challenges in the inner-city of Amsterdam in cases when large public events are held (such as large concerts). These cases typically result in a large influx of event visitors towards the inner city at peak hours, of which many travel by car. As a consequence, the available road infrastructure of the inner-city is unable to accommodate this large increase of road users, resulting in increased and more severe traffic jams and increased pollution. The city, therefore, sought after a collaborative solution involving parties, such as retailers, event providers and road authority, to mitigate or decrease the adverse effects of event-heavy periods on the road infrastructure and to regulate the traffic.

reduce the load for the road infrastructure. To provide this service, the resources of a platform provider (defined as the mobility broker), the municipality, road authority, parking providers, event location providers and event providers were integrated. To support the financial viability of the business model, retailers were included to compensate part of the parking fees (as event visitors would arrive early in the city, and therefore, serve as potential customers bringing increased turnover). The resulting business model design is presented in Figure 2.

To continue the development and concretization of the business model design, its viability (i.e., whether the design is

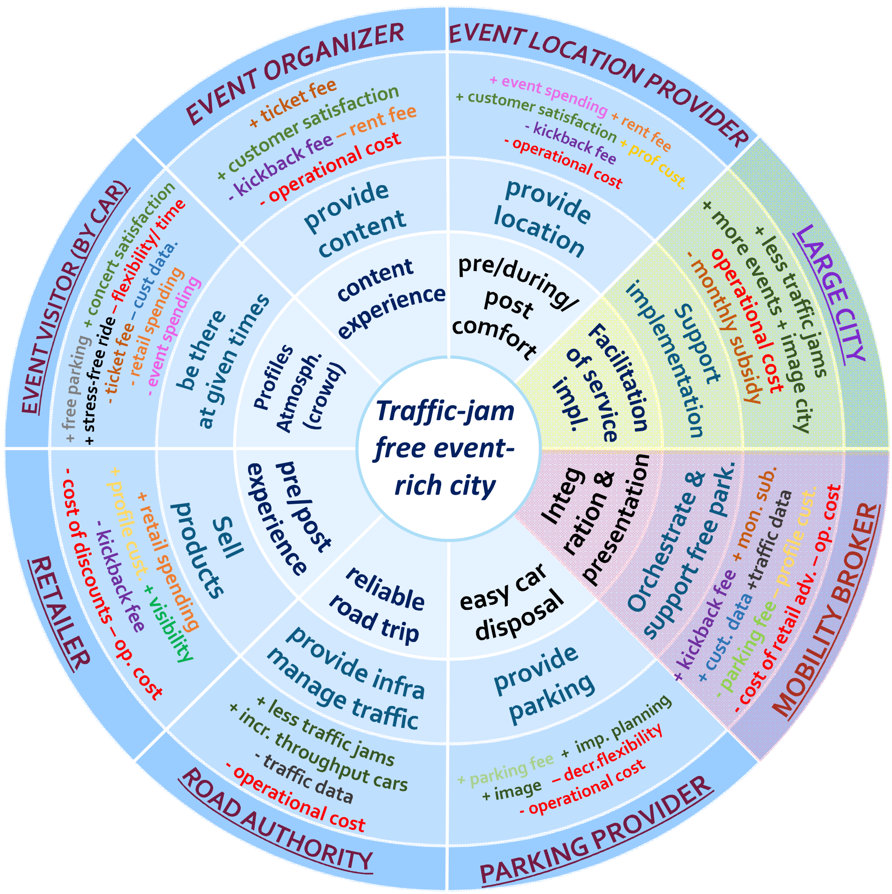

Figure 2: business model design for mobility case study

The solution that emerged from discussions with stakeholders entailed a platform to be accessed by event visitors, which would facilitate event visitors to indicate the event that they would attend by means of their event ticket. Through the platform, event visitors would then receive free parking tickets at designated parking providers in the city, *if* they arrive at the parking space in a pre-specified earlier time window. As parking is often expensive in large inner-cities (as is the case for Amsterdam), free tickets can motivate event visitors to arrive at the designated time. Through setting these arrival times in accordance with traffic density and behavior at that moment in time, the inflow of event visitors can -as a result- be regulated to

acceptable for all stakeholders involved) should be assessed. To communicate these preferences, we generated intentional linguistic summaries which describe the conditions under which the stakeholders would find it acceptable to participate. As many linguistic summaries can be generated based on the strategic goals of stakeholders, we focused on the most important goal per stakeholder that would drive acceptance of and further participation in the current business model design. Note that we therefore do not cover the complete set of ILSs (all protoforms), but only those that were deemed relevant to the stakeholders participating in the business model design.

For the stakeholders *mobility broker*, *parking provider* and *retailer*, we identified that the main motivation for them to participate in the business model is to generate increased profit. For instance, retailers contribute to the business model through a partial compensation of the parking tickets handed out to event visitors. The idea is that event visitors arrive early to the city and shop or eat in their spare time at the advertised retailers. They are not concerned with decreased traffic or satisfaction with the service. This scenario is only viable for the retailer if event visitors indeed visit the retail store and spend money for *most events*. As a quantifier, we did not consider *all* events as this would be too restrictive (as it can always happen that a single event results in a limited number of event visitors or limited spending at a retail store, which would violate the intentional summarization). Accordingly, to motivate participation, the retailer should make an *acceptable profit*. This '*acceptable profit*' is detailed further in later phases, and can be set to be higher than the current profit (e.g., without participation in the business model design). A similar case can be generated for the mobility broker and the parking provider, for whom participation also largely depends on the financial gains that would be generated. Accordingly, we have generated the following ILS for the *mobility broker*, *parking provider* and *retailer, respectively*:

"**On *most* events, the mobility broker makes an *acceptable profit***"

"On *most* events, the parking provider has an *acceptable increase in customers*"

"**On *most* events, the retailer makes an *acceptable profit***"

We have three separate ILS, to ensure the flexibility, e.g., in case when one party wishes to change their intentions, hence change the appropriate ILS.

The service offered should motivate *event visitors* to arrive early in the city in exchange for free parking. Whilst event visitors give up some of their flexibility in terms of arrival time and some of their privacy in terms of data to use the service, they gain the benefit of free parking. They also do not have to endure traffic jams as a result of arriving early (which results in less stress while driving). We summarize this balance of costs and benefits of using the service as '*event satisfaction*' (i.e., how event visitors perceive their experience). Ultimately, event visitors would participate in the business model design only if the service leads to *increased event satisfaction*. Therefore, we have generated the following ILS for the *event visitor*.

"For *most* events, most visitors enjoy *increased concert satisfaction*"

For the stakeholders: *event organizer* and *event location provider*, we identified that the participation in the business model for these parties is driven by the level of satisfaction that the event visitors have from the provided service. Only if this service is explicitly beneficial to event visitors (which in turn would likely benefit event organizers and event location providers through sustained event visits), event organizers and location providers would be willing to participate. Accordingly, we have generated the following ILS for the *event organizer* and *event location provider*.

"**For *most* events, *most* event visitors are *satisfied***"

Lastly, for the stakeholders: *large city* and *road authority*, participation is largely driven by the effectiveness of the provided service (which formed the basis for the design of the business model). The business model design is instigated to decrease severe traffic jams during event-heavy periods in the inner city. Therefore, *large city* and *road authority* are concerned with how well the provided service decreases these major traffic jams. As such, to motivate participation, we pose that through the business model design, almost none of the events should lead to a major traffic jam. We summarize this through the following ILS for the *large city* and *road authority*:

"***Almost none* of the events lead to a *major traffic jam***"

Using these intentional linguistic summaries as KPIs, stakeholders can explicitly specify certain conditions that they would pursue in participating in the business model. Through interpreting and understanding whether each ILS can be true, stakeholders can judge whether the current design is acceptable (and can advance to the next innovation phase to be further concretized), or whether the current design should be changed, as the ILSs can seemingly not be satisfied. In later phases of the business model lifecycle, these ILSs can, as explained, be extended further or deepened through fuzzy membership functions and verified by means of data that becomes available throughout its concretization and operation.

V. OUTLOOK

As mentioned above, ILSs can be further developed in later design phases and being transformed into traditional linguistic summaries, when the data are available. We will show this process on two ILS examples listed above.

As the first example, let us consider the ILS: "On *most* events the retailer makes an *acceptable profit*".

The *acceptable profit* (expressed in k€) is defined using a trapezoidal membership function [38], since it is easy to understand by domain experts, and easily computable. In our example, we can assume the acceptable profit as Trap(2.5;5;∞;∞), meaning that the retailer is fully satisfied when it has at least 5k€ of the profit per event. The quantifier *most* should also be defined, e.g., as Trap(0.5,0.7,1,1). Once the business model is operational, the truth value can be calculated for this ILS, in this case using a simple protoform formula, e.g., :

$$T = \mu_{most}\left(\frac{1}{n}\sum_{i=1}^{n}\mu_{Profit}(y_i)\right)$$

where n is the number of events that were executed within this business model, and y_i is the profit of these events.

If the truth value is above a certain threshold value, e.g., 0.7, it means that this ILS is valid and the KPI has been achieved. Otherwise, the business model should be changed.

As the second example we consider the ILS with two quantifiers: "For *most* events, *most* event visitors are *satisfied*". Visitor satisfaction can be measured, for example, with NPS (Net Promoter Score), which is on a scale 0-10 [39]. *Satisfied* can be defined as Trap(6,8,10,10). One could use two different quantifiers, but for simplicity purposes, we use same definition of *most*, as in the previous example (Trap(0.5,0.7,1,1)). Again, in the operational phase, after n events, the truth value can be calculated as:

$$T = \mu_{most}\left(\frac{1}{n}\sum_{i=1}^{n}\mu_{most}\left(\frac{1}{n_i}\sum_{j=1}^{n_i}\mu_{satisfied}\left(NPS_{ij}\right)\right)\right)$$

where n_i is the number of responders in the i-th event. NPS_{ij} is the response of the j-th participant in the i-th event. Again, if the truth value is above certain threshold value, it means that this ILS is valid and the KPI has been achieved. Otherwise, the business model should be changed.

VI. Concluding Remarks

In this paper, we have proposed the use of linguistic summarization to support business model design evaluation. In contrast to traditional linguistic summarization, we do not infer these linguistic summaries from data, but rather express these as intentions or conditions (ILS) for stakeholders in a business model design, which motivate participation. Early phases of business model design involves high uncertainty, which often makes it difficult to quantify the conditions under which the business model design would be acceptable for the involved stakeholders. Through the generation of intentional linguistic summaries, stakeholders can explicitly specify such conditions as performance criteria for acceptable business model design. Therefore, ILS can allow for a discussion on the benefits and costs without the need to focus too much on the details. These intentional linguistic summaries can consequently be used as KPIs to determine whether the business model design can be concretized further or whether the current design should be changed. Moreover, as the business model design is concretized in later phases of the business model innovation process with the availability of more accurate and detailed data, more precise ILSs can be specified such that these include fuzzy membership values for the definition of linguistic labels and validating the intentions expressed in ILSs by calculating the truth values of corresponding linguistic summaries.

Future work will include maturing the proposed method, e.g., by means of formalization and methodological guidance, as well as conducting the workshops and validating the method in practice. Initial results are highly encouraging, as we have received a positive feedback from workshops' participants where ILSs were briefly introduced.

References

[1] A. Osterwalder and Y. Pigneur, Business Model Generation: a handbook for visionaries, game changers, and challengers. New Jersey: John Wiley & Sons, 2010.

[2] T. Burkhart, D. Werth, J. Krumeich, and P. Loos, "Analysing the business model concept - A comprehensive classification of literature," Thirty Second Int. Conf. Inf. Syst., pp. 1–19, 2011.

[3] M. Morris, M. Schindehutte, and J. Allen, "The entrepreneur's business model: toward a unified perspective," J. Bus. Res., vol. 58, pp. 726–735, 2005.

[4] C. Zott and R. Amit, "Business Model Design: An Activity System Perspective," Long Range Plann., vol. 43, no. 2–3, pp. 216–226, 2010.

[5] M. Al-Debei and D. Avison, "Developing a unified framework of the business model concept," Eur. J. Inf. Syst., vol. 19, no. 3, pp. 359–376, 2010.

[6] R. McGrath, "Business models: A discovery driven approach," Long Range Plann., vol. 43, no. 2–3, pp. 247–261, 2010.

[7] T. Saebi, L. Lien, and N. Foss, "What Drives Business Model Adaptation? The Impact of Opportunities, Threats and Strategic Orientation," Long Range Plann., vol. 50, no. 5, pp. 567–581, 2017.

[8] C. Zott and R. Amit, Business model innovation: Toward a process perspective, vol. 395. 2015.

[9] K. Frankenberger, T. Weiblen, M. Csik, and O. Gassmann, "The 4I-framework of business model innovation: A structured view on process phases and challenges," Int. J. Prod. Dev., vol. 18, no. 3, pp. 249–273, 2013.

[10] J. Tesch and A. Brillinger, "The Evaluation Aspect of Digital Business Model Innovation: A Literature Review on Tools and Methodologies," 25th Eur. Conf. Inf. Syst., pp. 2250–2268, 2017.

[11] T. Schoormann, A. Kaufhold, D. Behrens, and R. Knackstedt, "Towards a Typology of Approaches for Sustainability-Oriented Business Model Evaluation," in International Conference on Business Information Systems, 2018, pp. 58–70.

[12] R. R. Yager, "A new approach to the summarization of data," Information Sciences, vol. 28, pp. 69–86, 1982

[13] J. Kacprzyk, "Intelligent data analysis via linguistic data summaries: a fuzzy logic approach," in Classification and Information Processing at the Turn of Millennium, R. Decker and W. Gaul, Eds. Springer-Verlag, Berlin, Heidelberg, New York, 2000, pp. 153–161.

[14] J. Kacprzyk and R. R. Yager, "Linguistic summaries of data using fuzzy logic," International Journal of General Systems, vol. 30, pp. 33–154, 2001J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73.

[15] J. Kacprzyk, R. R. Yager, and S. Zadrozny, "A fuzzy logic based approach to linguistic summaries of databases," International Journal of Applied Mathematics and Computer Science, vol. 10, pp. 813–834, 2000.

[16] J. Kacprzyk and S. Zadrozny, "Linguistic database summaries and their protoforms: toward natural language based knowledge discovery tools," Information Sciences, vol. 173, pp. 281–304, 2005.

[17] ——, "Fuzzy linguistic data summaries as a human consistent, user adaptable solution to data mining," in Do Smart Adaptive Systems Exist?, B. Gabrys, K. Leiviska, and J. Strackeljan, Eds. Berlin, Heidelberg, New York: Springer, 2005, pp. 321–339.

[18] R. Castillo-Ortega, N. Marin, and D. Sanchez, "A fuzzy approach to the linguistic summarization of time series," Multiple-Valued Logic and Soft Computing, vol. 17, no. 2-3, pp. 157–182, 2011.

[19] G. Smits, P. Nerzic, O. Pivert, and M. Lesot, "Efficient generation of reliable estimated linguistic summaries," in 2018 IEEE International Conference on Fuzzy Systems, FUZZ-IEEE 2018, Rio de Janeiro, Brazil, July 8-13, 2018, 2018, pp. 1–8.

[20] A. Jain and J. M. Keller, "On the computation of semantically ordered truth values of linguistic protoform summaries," in 2015 IEEE International Conference on Fuzzy Systems, FUZZ-IEEE 2015, Istanbul, Turkey, August 2-5, 2015, 2015, pp. 1–8.

[21] G. Moyse, M.-J. Lesot, and B. Bouchon-Meunier, "Linguistic summaries for periodicity detection based on mathematical morphology," in 2013 IEEE Symposium on Foundations of Computational Intelligence (FOCI), 2013, pp. 106–113.

[22] J. Kacprzyk, A. Wilbik, and S. Zadrozny, "Linguistic summarization of time series using a fuzzy quantifier driven aggregation," Fuzzy Sets and Systems, vol. 159, no. 12, pp. 1485–1499, 2008.

[23] ——, "An approach to the linguistic summarization of time series using a fuzzy quantifier driven aggregation," International Journal of Intelligent Systems, vol. 25, no. 5, pp. 411 – 439, 2010.

[24] M. Ros, M. Pegalajar, M. Delgado, A. Vila, D. T. Anderson, J. M. Keller, and M. Popescu, "Linguistic summarization of long-term trends for understanding change in human behavior," in Proceedings of the IEEE International Conference on Fuzzy Systems, FUZZ-IEEE 2011, 2011, pp. 2080–2087.

[25] A. Wilbik, J. M. Keller, and G. L. Alexander, "Linguistic summarization of sensor data for eldercare," in Proceedings of the IEEE International Conference on Systems, Man, and Cybernetics (SMC 2011), 2011, pp. 2595–2599.

[26] P. S. Szczepaniak and J. Ochelska, “Linguistic summaries of standardized documents,” in Advances in Web Intelligence and Data Mining, M. Last, P. S. Szczepaniak, Z. Volkovich, and A. Kandel, Eds. Springer Berlin Heidelberg, 2006, pp. 221–232.

[27] D. Anderson, R. H. Luke, J. M. Keller, M. Skubic, M. Rantz, and M. Aud, “Linguistic summarization of video for fall detection using voxel person and fuzzy logic,” Computer Vision and Image Understanding, vol. 1, no. 113, pp. 80–89, 2009.

[28] ——, “Modeling human activity from voxel person using fuzzy logic,” IEEE Transactions on Fuzzy Systems, vol. 1, no. 17, pp. 39–49, 2009.

[29] D. Anderson, R. H. Luke, E. Stone, and J. M. Keller, “Segmentation and linguistic summarization of voxel environments using stereo vision and genetic algorithms,” in Proceedings IEEE International Conference on Fuzzy Systems, World Congress on Computational Intelligence, 2010, pp. 2756–2763.

[30] A. Wilbik and R. Dijkman, “Linguistic summaries of process data,” in Proceedings of IEEE International Conference on Fuzzy Systems (FUZZIEEE 2015), 2015.

[31] R. M. Dijkman and A. Wilbik, “Linguistic summarization of event logs - A practical approach,” Inf. Syst., vol. 67, pp. 114–125, 2017.

[32] M. Delgado, M. D. Ruiz, D. Sanchez, and M. A. Vila, “Fuzzy quantification: a state of the art,” Fuzzy Sets and Systems, vol. 242, pp. 1 – 30, 2014.

[33] N. Marin and D. Sanchez, “On generating linguistic descriptions of time series,” Fuzzy Sets and Systems, vol. 285, pp. 6 – 30, 2016, special Issue on Linguistic Description of Time Series.

[34] H. De Vos and T. Haaker, “The STOF Method,” in Mobile Service Innovation and Business Models, 2008, pp. 115–136.

[35] O. Turetken, P. Grefen, R. A. M. Gilsing, and O. E. Adali, “Service-Dominant Business Model design for digital innovation in smart mobility,” Bus. Inf. Syst. Eng., 2019.

[36] P. Grefen, O. Turetken, K. Traganos, A. den Hollander, R. Eshuis Creating agility in traffic management by collaborative service-dominant business engineering”. Working Conference on Virtual Enterprises (PRO-VE 2015). Springer, Cham. 2015.

[37] O. Turetken, P. Grefen “Designing Service-Dominant Business Models” European Conference on Information Systems (ECIS-2017), 2017.

[38] L. A. Zadeh, “Computation with imprecise probabilities,” in Proceedings of the 12th International Conference Information Processing and Management of Uncertainty in Knowledge-based Systems, 2008.

[39] P.C. Mandal, P.C., “Net promoter score: a conceptual analysis”, International Journal of Management Concepts and Philosophy, 8(4), pp.209-219, 2014.