Redefining KPIs with Information Flow Visualisation – Practitioners' View

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***Abstract*—We investigate Key Performance Indicators (KPIs) in a large and multi-national telecommunication company and discover needs and requirements for understanding, analysing and using KPIs from practitioner's perspective. Utilising an action research approach, we identified the existing challenges with KPIs in a large-scale software-intensive systems development in a global setting. Our study revealed several issues with organisations KPIs, e.g., measuring the wrong things or not basing the measurements on reliable data. Based on the identified issues, a visualisation and modelling approach was introduced to reform the KPI representation and formulation to improve understanding and communicating KPIs, as well as their use in decision-making. We suggest that KPI information flow visualisation with appropriate tool support allows redefining usable, valid and reliable KPIs. The problem is addressed with a simple solution that is easily adopted and taken into use at all levels of an organisation.**

***Keywords*—key performance indicators; KPIs; modelling; visualisation.**

I. INTRODUCTION

Managing the development of software systems requires careful attention. Companies operate in turbulent environment with fierce competition and tight time-to-market requirements [1], where knowledge of the performance of the development process, in addition to understanding the system and its development is necessary [2]. Companies use Key Performance Indicators (KPIs) to provide this vital information. KPIs are used to measure, for example, the quality of the product, the features developed, the resources spent in the development and the value delivered to customers. KPIs provide a way to evaluate and improve the product and the process.

There is evident value in defining KPIs for the company. However, it is challenging to formulate KPIs so that they provide useful, valid and reliable information, and many organisations struggle to measure their projects, products and units [3]. Thus, our research question: "How to easily formulate KPIs so that they effectively and reliably measure the product development process performance?"

In this paper, we report an action research study, conducted within a large telecommunications company. The study revealed critical practical challenges in defining and using KPIs in organisation. For solving the challenges, the visualisation of the KPI information flow was found to be essential to provide a better understanding of the process. An approach and supporting tools were developed for the modelling and visualisation of the KPI information flow. Supporting the developers' understanding about the KPI formulation process resulted in KPIs that provide more real value for the organisation, and thus improve the KPI process. Visualisation and supporting tools provided means also to understand and communicate KPIs.

The rest of the paper is organised as follows. Section 2 discusses the related works, Section 3 presents the research approach, Section 4 presents the action research intervention and its results, Section 5 discusses the findings of the empirical work, and Section 6 concludes this work.

II. RELATED WORK

KPIs provide many kinds of information about the development, thus, it is important to select KPIs according to organisation's strategy and objectives [4][5]. Deep understanding of the software development process is needed—providing the understanding of the "why", "what" and "how", defining also the motivations and rationales for activities and flows [6]. Different stakeholders have different views of and needs for the process [6]: Process performers often focus on the "hows", process managers on the "whats", and process engineers on the "whys". Thus, different views are necessary, and KPIs address different needs. Our focus is on how KPIs are used and defined, as well as understanding KPIs and recognising stakeholders' views.

A. Formulating KPIs

Production of good KPI values starts from the reliable source data, but in practice it is hard to collect consistent and comparable data. Further challenge is to decide upon the importance of individual performance measures for decision-makers and prioritisation is a challenge as well. There are approaches that guide KPI work and measure organisational performance; some of them are shortly introduced next.

del-Rey-Chamorro et al. [4] presents a framework for creating KPIs for knowledge management solutions, with eight steps to create KPIs from the strategic level business plan all the way to operational level measurable KPIs utilising templates for KPI formulation and how to bridge the strategic level and operational level. The aim is to evaluate the effectiveness of knowledge management solutions.

Analytical Hierarchy Process (AHP) constructs a pairwise comparison between different KPIs and their hierarchies to evaluate and prioritise them based on SMART (Specific, Measurable, Attainable, Realistic, Time-sensitive) goal setting [5]. The focus is the prioritisation of KPIs to find

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the most relevant KPIs for the organisation [5]. However, it does not consider how KPIs should be formulated.

Balanced Scorecard [7] measures the organisational performance and aims at transforming the vision and strategy into concrete objectives, aligning departments and units towards common goals, etc. Yet, the following shortcomings are identified: Inaccurate and subjective measures, communication is not participative (only top-down), and inappropriate benchmarks are used for evaluation [8].

ISO standards provide guidelines as well. ISO 9001:2015 specifies requirements for a quality management system. It does not specifically mention "KPIs" but requires metrics to measure the system to ensure: a) the ability to consistently provide products and services that meet customer and applicable statutory and regulatory requirements, and b) aims to enhance customer satisfaction through the effective application of the system, including processes for improvement of the system and the assurance of conformity to the customer and applicable statutory and regulatory requirements [9]. ISO quality management principles [10][11] aims for customer focus, leadership, the involvement of people, process approach, system approach to management, continual improvement, factual approach to decision making, and mutually beneficial supplier relationship.

However, several challenges are identified in current ways for defining KPIs and ensuring that they are based on valid data [12]-[15]: Selecting and defining KPIs is not easy. KPIs are often defined in siloed terms instead of considering the whole organisation, e.g., they only focus on financial aspects and may lack the other aspects like manufacturing. Accurate calculations are hard to create and they easily measure something else than the intended objective. It is difficult to have metrics reflecting strategic drivers and be in line with the organisation's visions and goals. KPIs must also be aligned through the whole organisation and every level of work, from visions and goals to actual implementation. Local optimisation should be avoided, and short-term and long-term goals should be balanced. There are nuances and unforeseeable variables that affect the measures. Finally, KPIs must be put in practice in order to see how they impact the performance and behaviour, and they should be adjusted accordingly. Hence, continuous refining is necessary.

To address the identified issues, improvements are necessary. Properly selected and measured KPIs help decision-making, but getting the measures right requires considerable effort [16]-[18]: Even though the measures are classified into different categories, they are often correlated due to the inherent internal relations of different processes in the supply chain. Complex dependencies, changing goals and tight deadlines make organisations prone to making rushed decisions. Thus, it is important to have a simple way to identify and analyse the KPI data flows and relationships in order to avoid flawed decisions. Due to the complicated relationships, dependencies and conflicts, modelling the relationships is proposed and quick feedback loops are suggested. Furthermore, the goals and KPIs should be adjusted when they are no longer realistic.

In a nutshell, KPIs should be based on data that is available and measurable, and KPIs should provide relevant information. Effective performance measurement system "should provide timely, accurate feedback on the efficiency and effectiveness of operations" [19]. Measurements are also necessary for process improvement purposes—if it can't be measured it can't be improved [20].

B. KPI Visualisation

It is important to understand how to present the measurements and act accordingly. Visualisation helps ensuring that the actions are taken and transparency is achieved [21]. Benefits of KPI visualisation are many: Visualisation is an important factor in thought and communication [22]; Information visualisation and graphical representation help in complex cognitive tasks [23]; Information visualisation supports comprehension and data analysis [24], especially for non-technical users [12]; Visualisation enables smarter decisions and improved productivity [12]; Groups supported by visualisation achieve better productivity, the better quality of outcome and greater knowledge gains than groups without such support [24].

Often KPIs and different measures are correlated and create a complex network of interdependencies [18], thus, understanding the results and the process of formulating KPIs is challenging. Visualisation enables the analysis of activities, the flows (i.e., inputs and outputs), dependencies, and the contexts [25]. It can also be used to visualise the components where KPIs are built from, decomposing the higher level KPIs into lower-level components in order to trace the sources of problems [26]. Visualising the process can be done in several ways with different levels of formalism and detail (cf. [27][28]). Finding the correct level depends on the purpose.

There are examples to KPI visualisation, like del-Río-Ortega et al. [29], who propose an XML-based way for a graphical or a template-based textual notation for business processes. To help selecting the visualisation approach, Staron et al. [30] provide a model based on seven dimensions: type of reporting, data acquisition method, type of stakeholders, method of delivery, frequency of updates, aim of the information, and length of data processing flow. However, formal visualisation and modelling approaches can be cumbersome and "too heavy", e.g., for persons who are not familiar with process modelling concepts [25]. Thus, their benefits are lost. Instead, a simpler approach is proposed. Presenting detailed processes as higher-level entities makes the visualisations more comprehensible, and multiple views or representations for managing the complexity is suggested [25]. Rationale and justification for processes and activities must also be presented as those express why the work is needed. Rationale and reason tell what is meant to be accomplished and why [31][32].

III. RESEARCH APPROACH

The case company was chosen as it could provide data related to the research question. The case organisation is one of the largest data networking and telecommunication technology providers in the world in its field. The

organisation is distributed across the globe, operating in over 100 countries, with over 50000 employees globally. The case organisation uses both traditional and agile development methods, depending on the product and development teams. The role of KPIs in the company is to evaluate the performance and ability to meet the organisational goals of every product line. A number of factors make KPI design and calculation complex, like: a) vast number of product lines operating under different organisational units, b) different processes used by development teams, c) different data formats for work items, d) knowledge and data are distributed over several systems, e) several persons are required to handle knowledge and data, and f) copying of data from one format to another and one system to another.

To monitor their product development process, the case company utilised metrics that measure the process on different levels. Data was collected and analysed from various stakeholders to synthesise KPIs and analyse those with the aim to get an accurate picture on product development. The data was provided and calculated by multiple units, a part of the work was done manually and partly assisted by tools. The company was interested to minimise manual data collection and work and improve the tools, as well as the accuracy of the KPI process. In order to reach these goals, the company needed a method for collecting and structuring information to describe the current KPI process from multiple perspectives. It was seen that an action research intervention is needed to analyse the problem and provide improvements. A typical action research cycle is shown in Figure 1. The research started with a pre-study to familiarise the topic and understand the state of the practice.

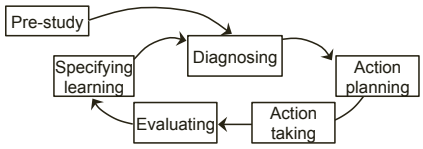

Figure 1. Research process [33].

Experts and managers from different levels of the organisation were interviewed. Eight production lines were involved with at least one production line manager from each attended the modelling session. In each modelling session, the product line manager was assisted with engineer working in the production line who could provide technical details when needed. The persons attending the modelling session were senior engineers or managers, each at least ten years of working in the company. Hence, the results represent the experiences in the case organisation.

In each iteration, the results of the previous iteration were presented first, i.e., the visualisation of the KPI process. In the diagnosing phase, the learnings were diagnosed to commence the action planning. This was done in co-operation with the company. Based on the diagnosis, actions were defined and then carried out. Actions were conducted by implementing a construct and applying it in its intended settings, thus, providing empirical evidence of its use. The action taking phase lasted over two months to ensure the agreed actions were implemented. Then, the results were evaluated and discussed in a workshop. Based on the evaluation and workshop, the learning was specified.

The action research cycle was repeated four times during the study consisting of a total of 30 modelling sessions with 20 stakeholders and 5 analysis workshops. In the modelling session, each participant's viewpoint to the process was modelled and visualised by the researchers, who asked the developers and experts to present the process from their own perspective. The participants were asked to think out loud so that the researchers could understand what they were thinking of. Questions were also asked to elaborate things when necessary. These sessions were also recorded for later use. Researchers made notes and observed the use of the construct. After each evaluation phase, experiences were discussed in a meeting. Gathered feedback, observed challenges and identified issues in the construct were documented. The researchers and the case company representatives also held regular meetings to review the results and decide on further actions. These actions provided rich data for analysis and for specifying learning.

Soft Systems Methodology (SSM) was selected as a basis for our modelling approach. SSM, a problem structuring method popularised by Checkland [34], was applied in the study for structuring KPIs and the KPI process. SSM was chosen because it is an efficient way to understand and address the complex situations, especially when there is no clear problem definition, and it is also useful for information visualisation, to show flows, bottlenecks, inconsistencies and contradictions. It also supports information discovery and decision-making, and it frees cognitive resources that can be used for, e.g., solving development problems [22][35]. Figure 2 presents the basic elements of our approach.

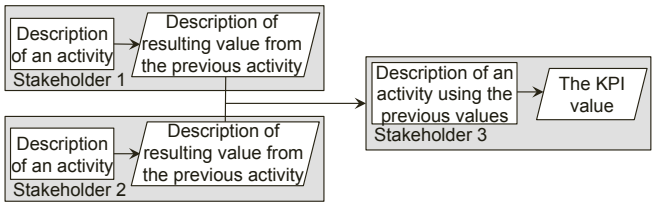

Figure 2. Basic structure of a KPI.

In this approach, practitioners simply model the values and activities from their perspective, regardless of whether the activity or data matches the documented KPI descriptions. It gives the building blocks utilising existing UML notations. Enabling users to construct representations from their perspective and viewpoint is important, as it helps them to come up with solutions to problem issues, and enables them to know what to do next [4].

IV. RESEARCH EXECUTION

The action research intervention consisted of pre-study and four action research cycles. In the pre-study, existing company documentation defining their KPI structure, visualisation and implementation was analysed. The provided information described the intent of each KPI and how those should be formulated. In addition, the company provided a list of persons and organisational units that were

involved in the KPI process, including also description how they provided or processed KPI information in the process. In addition, related research was also analysed.

A. First Action Research Cycle

DIAGNOSING: The pre-study revealed that the system was more complex than the company documentation indicated. The process included hundreds of stakeholders and multiple variations of the data items. Based on the pre-study, it became necessary to study the overall information flow and stakeholder involvement to determine how the actual system providing the KPIs was structured.

ACTION PLANNING AND TAKING: The plan was to start the KPI system modelling with the pre-study information to formulate a proper soft system model based on SSM. UML flowchart approach and SSM [34] were used to create a KPI soft system model.

EVALUATION AND LEARNING: At the end of the first cycle, the resulting model was evaluated in a workshop with the company representatives. The participants agreed that the model allowed examining KPIs in more detail, which showed that the company documentation did not represent the real KPI behaviour or process. The lack of information about how the data is obtained, undocumented sources, how data is created and how data is used in the decision-making demonstrated that KPIs did not present accurate information or what KPIs were intended to present. Moreover, a simple collapse/expand feature was requested from the tool hiding the complexity or bringing out the details when needed. Participants agreed that this kind of feature would improve visualisation and understanding. Finally, a decision was made to include the stakeholders of KPI modelling in the next research cycle to provide the information missing from the model.

B. Second Action Research Cycle

DIAGNOSING: At the previous cycle, the soft system model of the KPI process showed that there was missing information and dead ends not documented in the official documentation. This indicated that there are information only known by involved stakeholders and they should be contacted to provide the missing information.

ACTION PLANNING AND TAKING: The plan was to involve the stakeholders to add the missing information to the model. The stakeholders who would know how data items were created or what information was used to create them were invited to a modelling session, where the information provided by the stakeholder was added to the soft system model created in the previous research cycle. Each modelling session continued updating the same KPI soft system model created in the first cycle. After the sessions, a workshop was organised to evaluate, correct and analyse the KPI soft system model.

EVALUATION AND LEARNING: The new version of the soft system model was discussed with company representatives in a workshop. Based on the analysis of the soft system model, workshop participants thought that the visualisation was complex. They suggested that using stakeholder viewpoints allowed adjusting abstraction levels to manage the complexity. With viewpoints, they were able to examine selected parts of the process and keep the visualisation comprehensible. The feedback for the soft system model indicated that it allowed stakeholders to understand how KPIs were constructed and the model offered enough information to interpret KPIs correctly. According to the participants and the analysis in the workshop, both the UML visualisation and SSM principles created a KPI model that was easy to interpret, translated concepts from one domain to another in a meaningful way and allowed the evaluation of KPIs. Finally, the participants considered it necessary to adjust the way the model was created to support simpler notation and logic to allow users with varying experience to contribute. They thought that the current approach was labour intensive and required deep knowledge of modelling and SSM methodology, which was seen as hindrance as it required an expert to help.

C. Third Action Research Cycle

DIAGNOSING: The ability to understand how KPIs actually work was very important for the company personnel as the KPIs did not work as intended and they did not provide the correct information. The modelling of the KPI process needed to continue to provide a better big picture. However, the process needed to be simplified, allowing anyone to understand it and input his or her own viewpoints without the help of the researcher or an expert.

ACTION PLANNING AND TAKING: The existing KPI soft system model was transformed to a digital format utilising Microsoft's Visio tool, allowing anyone to access the model at any time. In addition, the participating stakeholders, developers and managers were taught the modelling method so that they could add their own viewpoints. Teaching the approach also allowed the researchers to develop it further and make it easier to understand and learn. In addition, modelling sessions were continued with those stakeholders who preferred to work with the researchers instead of doing the modelling alone.

EVALUATION AND LEARNING: At the end of the cycle, a workshop was held to discuss the results with all company stakeholders involved in the cycle. Based on the discussion and analysis of the new version of the KPI soft system model, it was quickly noticed that the selected visualisation approach was approved and the process representation it provided was very informative and usable. The KPI soft system model provided a shared understanding about the process and work activities regardless of the expertise or work position. It was easy to discuss the specifics of the process with the representation as a reference point, where each participant could pinpoint the activity or information flow they were interested in.

Further, the findings from second research cycle were re-examined, as more data was available from different teams and product lines. The model started to show its efficiency, as it confirmed that the data that the organisation bases its KPI measurements is not sufficient and that lead to situation where KPIs were not indicating the measurements that they were intended to do. For example, two different organisational units could get different figures based on their

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source information or interpretation during the data handling. Another concrete example was that the calculation of delivered backlog items didn't take into account the size of the items or items finalised by collaborators, thus, resulting in skewed efficiency measures. Finally, simplifying the modelling process was seen as a way to speed up the modelling process and to help others to understand the modelling process and the modelling language [cf. 36]. This also allowed persons with no prior knowledge on UML to understand process and contribute.

D. Fourth Action Research Cycle

DIAGNOSING: Diagnosis of the previous action research cycle called for an analysis of KPIs and presentation on how they can be re-constructed as meaningful KPIs that accurately reflect the development process. Furthermore, additional focus was needed on KPI visualisation due the growing amount of information in a single model. A proper system visualisation was required from different stakeholder perspectives in order to effectively communicate the KPIs to different levels of management, developers and support staff.

ACTION PLANNING AND ACTION TAKING: Based on the diagnosis, this action research cycle was focused on analysing which KPIs the company would benefit on utilising, and use that information to propose how the previously modified KPIs should be constructed. In order to do so, in addition to the existing model, a new KPI soft system model was created to represent the meaningful and accurate KPIs perceived by company management. In addition, special attention was given to the viewpoints to make the visualisation easier to read. The analysis and modelling were done in separate sessions with management stakeholders, similarly to previous research cycles. After a selection of 8 KPIs was fully remodelled, they were compared to the original KPI soft system model to show the current implementation and how the KPIs should be changed to match the desired situation.

EVALUATION AND LEARNING: After the action planning and taking, a workshop was held with all participants. Based on the workshop discussions, it was clear that the stakeholders preferred this approach as it provided the following benefits: 1) It allowed stakeholders to see the current situation and what should be made to the existing KPI system to have meaningful KPIs. 2) The model showed the disparities between stakeholder viewpoints that weren't visible before and the visualisation enabled effective communication on disparities. 3) The resulting model allowed practitioners to re-evaluate their current process and data in order to determine the best course of action. 4) The model was easy to comprehend and it provided reliable results that were accurately reflecting the state of the process.

The fourth action research cycle was the final iteration, as the results were satisfying for both researchers and case organisation. The resulting model worked as the description of KPIs and allowed to construct, analyse and describe KPIs with a single model. The participants also agreed that the measures could now be relied upon, and the KPIs showed effectively what they were supposed to show.

V. DISCUSSION

Our action research intervention revealed several issues with the organisations KPIs and KPI formulation process. The company's process provided KPIs that did not fulfil their intended purpose. There was a clear need to understand the process better—to know more about the reasons KPIs were used for and from what source data the analyses were done from. This called for modelling the KPI information flows from stakeholders' perspectives that contribute to or calculate any KPI data. The focus was to provide visualised and accurate KPIs. Table 1 summarises our findings.

TABLE I. SUMMARY OF THE MAIN FINDINGS

Finding	Implication
Describing KPI as an information flow allowed stakeholders to comprehend the actual meaning of KPI versus what was described in the official documentation.	- Modelling, visualisation and constant analyses are necessary to find out the relevant KPIs and to keep the KPI process up to date. - Modelling and visualisation enables to see where the data originates and how it is manipulated. - Modelling and visualisation enables simplification. - Modelling and visualisation enables the evaluation of the validity of the data and whether KPIs perform as intended.
Visualising the KPI information flow eased communication between stakeholders with different backgrounds.	- Visualising the workflow improves the coordination and understanding of others work. - Modelling and visualisation enables more accurate analyses, reveals bottlenecks and problem areas, and finally makes possible process improvement activities. - Visualisation improves understanding and communication.
Showing different stakeholder viewpoints as a part of the information flow allowed comprehension of KPI, data items and complexity of the implementation in different parts of the organisation.	- Viewpoints can be used to adjust the abstraction levels and to manage the complexity. - Hiding and expanding parts simplifies the presentation. - Viewpoints allows for focusing on the matter at hand. - Modelling tools should provide viewpoints functionality.
Allowing stakeholders to see their viewpoints and modify them motivated stakeholders to participate and extend the model further.	- Understanding the process for KPIs is paramount for motivation. - Modelling KPIs reveals information on how the data is obtained and created, and how it is used in the decision-making. - Showing the viewpoints help understanding and agreeing upon the perspectives (e.g., quality vs. efficiency).
With the proposed approach the KPI information flow model became both the actual description and formulation of a KPI.	- Stakeholders should be involved in the modelling. - Accurate and reliable source data is required for meaningful KPIs. - Measurements and comparisons over the product lines can be achieved.

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Utilizing common UML-tools (e.g., Visio) and the modelling method presented in [36] as our tools we could provide the visualisations. With the help of the visualisations, the case organisation personnel understood better KPIs and how they were formulated, and they noticed serious flaws. KPIs were neither reliable nor commensurable between different units or product lines, e.g., there was inconsistency with measurements, as management focused on effectiveness and engineers focused on quality. In sum, visualisation made the organisation rethink their KPIs and how they are formulated.

Visualisation revealed that the source data was different than originally understood by those who formulate KPIs, providing different results than what originally was intended, and hence decisions were made based on flawed KPIs.

Furthermore, KPIs were not immediately available, instead data was gathered once a month and KPIs were then calculated, KPI data was different between product lines/units, and KPI process had unnecessary workload and loops. One of the key findings was that the changes to the existing process did only change the local processes and work; it did not guarantee that KPIs were changed elsewhere. It was realised that in order to properly formulate KPIs, the whole KPI process and its information flows should be analysed, not just the data sources. Based on our study, we propose that KPI visualisation as a flow is necessary for recognising who is contributing and what data is used in that contribution. It also helps to see if KPIs provided by different teams are commensurable.

The study showed that KPIs were found problematic, as they are often taken for granted and the way that KPIs are implemented is not visible for stakeholders. It is seldom considered where KPIs come from and what they are representing. It is necessary to think carefully what calculations are useful and whether those calculations reveal the issues they are meant to.

Figure 3 below presents a KPI example that shows the average development hours of two different products. In this example, two teams work for product A and input their working hours directly to Jira for each feature. For product B, the product owner estimates the working hours spent on each feature based on team members compiled a list of features. The example presents a visualised KPI that informs what is the source data used to calculate the KPI and how it is formed. With proper tool support, the data and activity elements can be made to represent real data. Essentially, the visualisation allows stakeholders to identify and ask the questions that matter in regards to validity, representation and usage of a KPI. With a systematic analysis, we found the issues with KPIs and KPI formulation process. Modelling and visualisation enabled the stakeholders to understand the KPI process better and it made the stakeholders think about the relevant data and information concerning KPIs.

With our approach, a soft system model could be built systematically. The model showed where the data originated and how it was manipulated throughout the process. Thus, validating the usefulness of our approach to modelling of KPI information flows. We believe that our approach would be fit for other cases also, however that still requires further validation. Due to improved understanding, modelling and visualisation was found useful as a process improvement tool: It allowed the identification of problems in the process, and unnecessary activities could be identified and the process could be streamlined accordingly. Coordination of activities was also improved.

Our modelling and visualisation approach addresses several needs and is generic enough to be used in various situations and purposes. Our approach is suitable for visualising and analysing the activities and information flows, and showing the dependencies. Moreover, it was easily adopted and personnel committed to use it. Presenting the KPI process as a graphical model provided better understanding for developers and experts, and it also improved communication and helped to analyse the work. It motivated the personnel and they came up with new ideas to further improve their work, work practices and processes. Visualisation was also found to be useful in pinpointing the bottlenecks and problem areas.

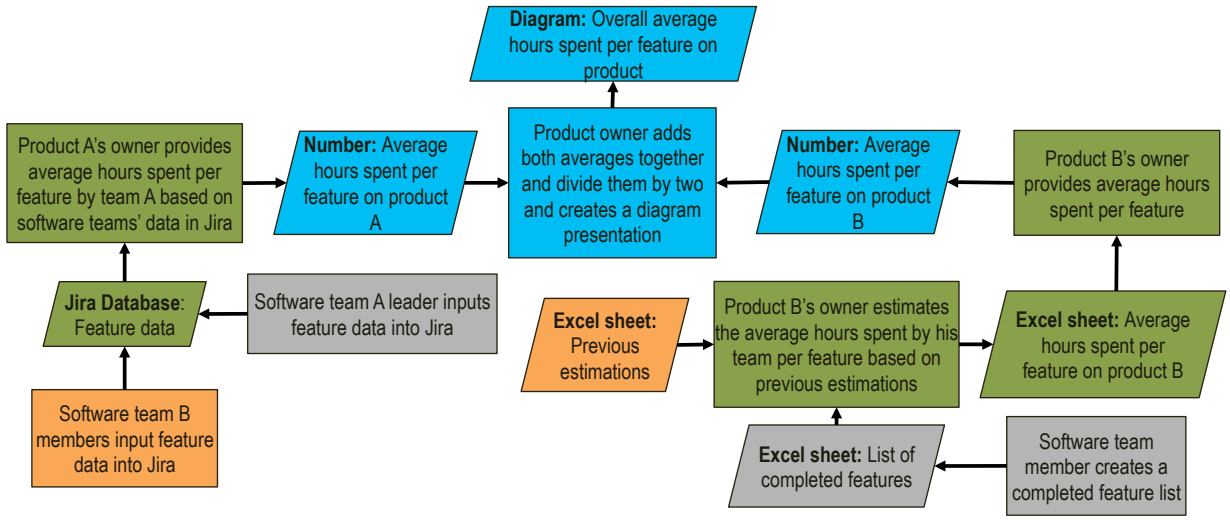

Figure 3. Example KPI formulation for a system.

Being able to construct representations also improve the readability of visualisations [37]. Our approach complements, e.g., the dashboard selection model by Staron et al. [30] and ways to elicit information by Staron et al. [38], which is more based on a set of questions, and it can also be used as a simple visualisation mechanism on top of other established approaches, such as Balanced Scorecards by Kaplan and Norton [7]. The findings are also in line with Staron [3], stressing the importance of completeness, reliability and early warning signs.

A. Validity of the Study

The reliability of the data and results was ensured via rigorous research protocol with peer reviews by researchers and company representatives. The action research cycles were documented throughout the research. The modelling sessions were recorded and transcribed by the researchers.

The way the action research was implemented introduces a danger of positive bias within researchers and company participants—due to the constant communication and interventions; the company participants could be positively biased, producing only positive results. However, having many different viewpoints presented in the workshops and modelling sessions addressed this issue. Also, agreement over clear roles and rigorous research methods helped participants remain neutral observers.

This study was conducted within a large ICT organization that utilizes product line based development, hence limiting the generalizability of the results. In order to make wider conclusions more domains, smaller companies and different production models should be studied.

VI. Conclusion and Future Work

This paper presents an action research study with the aim to understand organization's KPI process and to formulate a meaningful set of KPIs. Several issues in the case organisation were identified during the study, with the most significant being that the original KPIs didn't measure what they were intended to measure. KPIs were not giving the right information; they were not well defined and were not based on complete and reliable information. When the information was not correct, it caused harm as the decision-making was relying on false data.

Modelling and visualisation was used to understand, analyse and to model the KPI process. Using simple visualisation mechanisms to model and represent the KPI process helped in understanding the purposes and needs of measurements, as well as the source data and its handling during the KPI process. Modelling and visualisation also clearly revealed the different stakeholders that participated in the KPI process, and further improved understanding and communication between the stakeholders; especially non-technical persons' understanding was improved considerably.

The improved KPI process and well-defined KPIs, in turn, lead to more effective decision-making, as the measurements were more accurate, reliable and descriptive. Also, different units and product lines could be compared when the measurements were commensurable.

Study showed that the KPI information flow should be carefully analysed and KPIs should be based on real needs and real measurable values. To address our research question, KPIs should be formulated in a way that provides real results. For this purpose, the proposed modelling and visualisation approach is a very useful tool. It allows for redefining usable, valid and reliable KPIs so that KPIs and the whole KPI process, with all the interdependencies, can be well understood and analysed. It is also important that the whole product development process is analysed, not just the data sources for KPIs. Analysing the process provides an understanding how KPIs are build from the original data, what the measurements really indicate and how they can be used to understand and improve the development process. Constant follow up and process refining is also an integral part of the process, which helps to keep the KPI process always up to date.

Our approach solves many issues related to KPIs and it is useful especially when there are several teams working on their tasks and the overall picture may be hard to see. Our approach concretises abstract work and defines the relationships of activities associated to it. It provides graphical presentations that are accessible and easy to use for understanding, analysing, communicating and improving processes. The resulting model can be used for presenting the actors, activities and information flows, and describing their logical order and dependencies. Graphical models and modelling helps in understanding the complex problems by enabling breaking those down to understandable entities.

This work benefits both research and industry. Research benefits from new knowledge and the experiences from the industry to expand the knowledge base. Industry practitioners can adopt a simple modelling and visualisation approach to improve their KPI process. We propose simple modelling and visualisation as a recommended practice in formulating KPIs, especially in sociotechnical systems, where persons are in interaction with technology. The solution is simple on purpose. The problems are common in industry and, e.g., in the case organisation the heavy weight solutions have not been useful – they have not been well embraced. However, simple and intuitive solutions are more easily taken into use also at the lower levels of an organisation.

Topics for further studies were also identified, including confirming the results in other domains to improve the generalizability. Furthermore, the question about how to help organisations to act upon KPIs and implement the changes still remains.

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