Towards Process-oriented Information Logistics: Why Quality Dimensions of Process Information Matter*

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Abstract: An increasing data overload makes it difficult to deliver needed information to knowledge-workers and decision-makers in process-oriented enterprises. The main problem is to identify information being relevant for process participants and their activities. To cope with this challenge, enterprises crave for an intelligent and *process-oriented information logistics*. The major challenge is to provide the right process information in the right format and level of granularity at the right place and accurate point in time to the right actors. When realizing such process-oriented information logistics it becomes crucial to take into account quality dimensions of process information (e.g., completeness, topicality, punctuality). Reason is that these dimensions determine *process information quality* and thus also the overall relevance of process information for a particular process participant and his activities. This paper picks up this issue and analyzes different quality dimensions of process information and their impact on process-oriented information logistics.

1 Introduction

Market globalization has led to massive cost pressure and increased competition for enterprises. Products and services must be developed in ever-shorter cycles and new forms of collaboration within and across organizations are continuously emerging. As examples consider product engineering processes [MHHR06] or the treatment of patients in an integrated healthcare network [LR07]. To cope with these challenges, effective *business process management* (BPM) [Wes07] becomes success-critical for enterprises.

BPM technology has focused on the modeling, analysis, and execution of processes (e.g., using BPM systems) [MRB08] in recent years. What has been neglected so far is the support of knowledge-workers and decision-makers by providing personalized process information to them depending on their current *work context*. The latter determines the information a process participant needs in order to perform current and newly upcoming

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activities. For example, to prepare his ward round a doctor needs information about his patients. Besides process-related information (e.g., the current activity), the work context also comprises device-related information (e.g., display size, bandwidth), location-based information (e.g., GPS location), and user-related information (e.g., user name, role, department). Overall, an extensive amount of process information is provided within and across organizations using techniques and tools such as e-mail, shared drives, Web 2.0 applications, and enterprise information systems [LL09].

Before characterizing the notion of *process information*, we first have to define the terms *data* and *information*. In literature, respective definitions are broadly diversified [Row06]. In the context of our research we apply the definitions suggested in [BCGH06, RT08, AG04]: *data* are raw facts or observations of things, events, activities, and transactions that are recorded and stored, but are not organized and processed, and therefore do not convey any specific meaning. *Information*, in turn, refers to data that has been organized and processed for a specific purpose. Consequently, it has a meaning and provides some value to the recipient. Generally, data turns into information, if someone is interested in this data. For example, a doctor might be interested in the blood group of a particular patient or the patient's maximum and minimum body temperature during a day. Besides, information can be also derived from data. As example consider the average body temperature that can be calculated from the individual temperature data items. Consequently, the difference between data and information is not structural, but functional [Ack89].

Analogously, we define *process information* as follows: *process information* refers to data that has been processed to support process users in the modeling, execution, monitoring, optimization, and design of processes. Hence, the data gets a meaning and has a value with respect to the process users' activities. Typical process information includes, for example, process descriptions, working guidelines, process models, operational instructions, forms, checklists, and best practices (e.g., documented in text documents, spreadsheets, presentations, and e-mails).

However, the mere availability of process information is not sufficient to adequately support knowledge-workers and decision-makers in their daily activities. What enterprises need is an intelligent, *process-oriented information logistics*, i.e., the right process information must be provided in the right format and level of granularity at the right place and accurate point in time. More precisely, process-oriented information logistics deals with the planning, execution, and control of process information flows within or between enterprises to support knowledge-intense business processes implying human interaction and decision making [BD08]. In this paper, we address one first aspect of an effective process-oriented information logistics: quality dimensions of process information.

Based on the question whether process information fulfills certain quality requirements, the overall relevance of process information can be determined. Picking up our healthcare example, typically, it becomes necessary that patient information is up-to-date and complete in order to be able to charge certain services through the accounting and billing department. Therefore, patient information which is out-of-date or incomplete is not relevant, since it cannot be processed by the medical accounting. However, depending on a specific work context, different quality dimensions might be more or less important than others. For example, for a surgeon, patient information should be available punctual and up-to-date. Conversely, for an employee being responsible for patient admission, information about the patient must be complete and error-free. Therefore, depending on the work context, a different weighting of the individual quality dimensions becomes necessary.

In fact, the consideration of work context and quality dimensions of process information is key to identify relevant process information. Figure 1 shows the relationship between work context and process information quality. On the one hand, the work context determines the process information a process participant needs to perform current activities. On the other hand, the use of quality dimensions allows to determine process information quality. Together, both aspects allow to determine the overall relevance of process information.

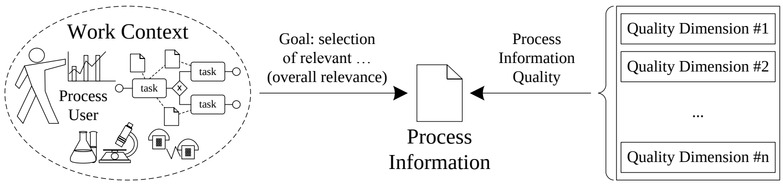

Figure 1: Determining the relevance of process information.

The presented research is performed in the niPRO project. In this project we apply semantic technology to integrate process information within intelligent, user-adequate *process information portals*. Our overall goal is to support knowledge-workers and decision-makers with the needed process information depending on their current work context. So far, both research and practice do not address how processes and related process information can be effectively merged. Currently, conventional methods of information retrieval or enterprise search engines are mainly used for this purpose. Opposed to this, the niPRO process information portal aims at determining required information for knowledge-workers and decision-makers dynamically and automatically. Key challenges include the personalized provision of process information, flexible visualization of process information, and innovative design approaches for different levels of information granularity.

This paper is organized as follows. Section 2 presents a running example that will be used throughout the paper. Section 3 investigates quality dimensions of process information. Section 4 discusses why contextual quality dimensions are particularly important. Section 5 discusses related work. Section 6 concludes the paper with a summary and an outlook.

2 Running Example

To illustrate different quality dimensions of process information, we use a running example from the clinical domain. This example is based on experiences we gathered during an exploratory case study at a large German university hospital [MMR11]. In this case study we analyzed the process of an unplanned, stationary hospitalization, including patient admission, medical indication in the anesthesia, surgical intervention, post-surgery treatment, patient discharge, and financial accounting and management.

Our running example (cf. Figure 2) specifically picks up the doctor's ward round. First, the ward round is prepared, i.e., the doctor has a look at patient information and current medical instructions (e.g., endoscope, physical therapy). Next, the doctor communicates with the patient and asks for information about his status. Afterwards, the patient is examined. This activity includes the analysis of blood values, vital values, and further follow-up diagnosis. Finally, the doctor creates medical instructions and updates patient information.

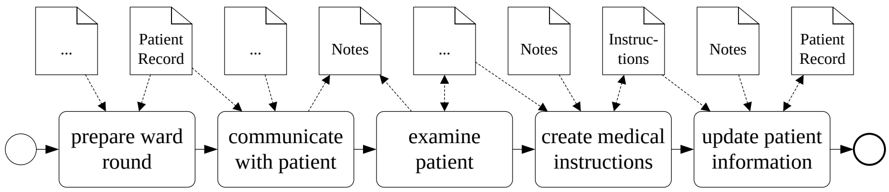

Figure 2: Our running example.

For each of these activities different process information is needed. For example, to perform activity "create medical instructions" a doctor needs blood values, vital values, notes, and current medical instructions. Conversely, to perform activity "update patient information", the doctor needs output information (e.g., notes, instructions) of other process activities and also access to the patient record. Note that the illustrated process information (e.g., notes, instructions, patient record) from our running example should be viewed only as a small part of all relevant process information.

To determine which process information is relevant in a specific work context, we now take a closer look at quality dimensions of process information. This way, we can ensure that process information meets necessary quality requirements (e.g., contextual relevance, free-of-error, objectivity, and believability), fits with the work context, is suitable for specific activities, and can so be easily used by process users.

3 Process Information Quality

Apart from very broad characterizations such as "fitness for use" [TB98] there exists no commonly accepted understanding of the term *information quality*. In fact, giving a single definition of information quality is difficult as this term is widely used in many areas. In this paper we define *process information quality* as a set of quality dimensions.

Process information quality can be investigated from various viewpoints, e.g., integration, transmission, security, storage, access, and representation. According to the goals of the niPRO project, we focus on the viewpoints of *integration*, *semantic processing*, and *provision*. Integration concerns the collection of process information from different data sources (e.g., databases, enterprise information systems, shared drives). The viewpoint semantic processing implies semantic analysis, processing and linking of process information. The provision viewpoint, finally, deals with the technical provision of process information.

Quality categories and quality dimensions described in the following were gathered based on a literature study, two qualitative exploratory case studies, and an additional online survey [MMR11, HMR11].

3.1 Quality Categories of Process Information

Quality dimensions of process information can be combined into different *quality categories*. Each category subsumes a set of dimensions. All dimensions belonging to the same category are affected by the same influencing factors such as work context (e.g., process- and user-related information) or information systems characteristics (e.g., representation of information). Specifically, we apply the classification of Wang [WS96] and Moore & Benbasat [MB91] and introduce four quality categories (cf. Figure 3):

- The *Intrinsic* quality category (QC1) integrates self-contained quality dimensions of process information. Quality dimensions from this category are independent on the work context. Examples include believability (e.g., to improve the believability of a medical diagnosis several doctors have to approve it) and objectivity (e.g., to guarantee the objectivity the health of patients must be determined by certain criteria and not by estimation). Another example is free-of-error (e.g., to achieve error-free patient lists, name and identification number of the patient must match).

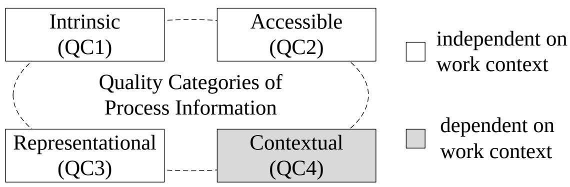

Figure 3: Quality categories of process information.

- The *Accessible* quality category (QC2) combines quality dimensions being important for the access to process information. These are mainly affected by the information systems providing process information. Examples of respective quality dimensions are accessibility (e.g., to treat a patient the doctor needs the patient record) and security (e.g., ensure the security so that specific process information is only accessible to authorized users).
- The *Representational* quality category (QC3) subsumes quality dimensions concerning the representation of process information. This quality category is again mainly influenced by the information systems providing process information. As examples of respective quality dimensions consider interpretability (e.g., the exact unit of measurement is always indicated for the given values), understandability

(e.g., addresses should not be displayed as GPS coordinates), consistent representation (e.g., patient information should be display consistently), and concise representation (e.g., current diseases are displayed separately from pre-existing diseases).

- The *Contextual* quality category (QC4) integrates quality dimensions which are influenced by the work context of process users. Contextual quality dimensions are, for example, contextual relevance (e.g., a doctor performing activity "prepare ward round" gets other process information than in activity "create medical instructions"), completeness (e.g., patient information must be completely available), and punctuality (e.g., blood values must be available when the doctor needs it). These quality dimensions always depend on the current work context.

In the next section we restrict ourselves to the contextual quality category. We do this because this quality category is particularly influenced by the work context and thus also by process-related information.

3.2 Contextual Quality Dimensions of Process Information

We distinguish between nine contextual quality dimensions of process information (cf. Figure 4). Each dimension is described in the following.

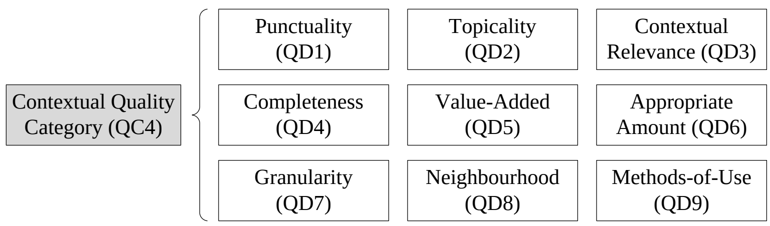

Figure 4: Contextual quality dimensions of process information.

3.2.1 Punctuality

The *Punctuality* quality dimension (QD1) indicates whether process information is provided punctually when the process participant needs it. Specifically, three different time points (t) have to be distinguished: (a) the point in time at which the process user *requests* the process information, (b) the point in time at which the process information is *provided*, and (c) the point in time at which the process user *applies* the process information. Based on this we can determine whether process information is punctual or not.

Additionally, it becomes necessary to distinguish between *ad-hoc process information* and *regular one*. The former is requested spontaneously. For example, a doctor may request blood values in order to be able to make decisions. Ad-hoc process information is accurate in time if it is provided between the point in time it is requested and it is used (cf. Figure 5). The length of this period depends on the process participant.

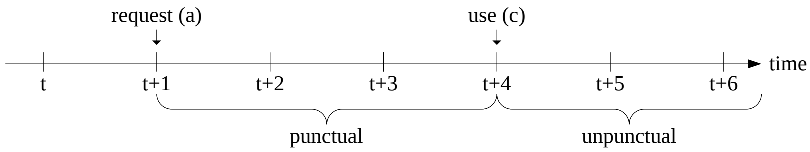

Figure 5: Punctuality of ad-hoc process information.

Conversely, regular process information is provided at pre-defined points in time. For example, every morning a doctor may receive a patient list in order to know which patients he has to visit. The punctuality of regular process information can be distinguished between two time points: (a) punctual in respect to the provision and (b) punctual in respect to the use (cf. Figure 6).

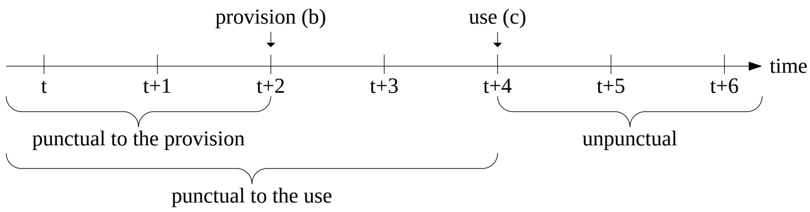

Figure 6: Punctuality of regular process information.

3.2.2 Topicality

The *Topicality* quality dimension (QD2) indicates whether process information captures the current characteristics (e.g., name, insurance agreement) of an object (e.g., patient) at the current point in time (t). Process information is out-of-date if the characteristics of the object have changed between the time point of *capture* and the time point at which the process user *applies* the process information (cf. Figure 7). For example, a body temperature of the patient measured two days ago is most likely obsolete. In practice, the capture of characteristics is often time-consuming. Characteristics of an object may continuously change (e.g., body temperature of a patient, health of patient). The capture can be done either in real-time (e.g., using heart rate monitor) or at pre-defined time points (e.g., during the ward round).

3.2.3 Contextual Relevance

The *Contextual Relevance* quality dimension (QD3) indicates whether process information is relevant in a specific work context. Process information has a high contextual relevance

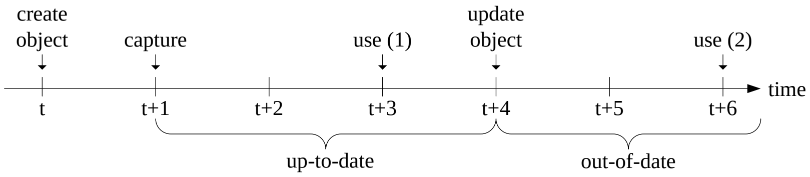

Figure 7: Topicality of process information.

if it is needed to perform or support an activity. For example, for preparing the ward round a doctor needs current diagnoses and medical instructions. The more precise a work context can be defined the more accurate the contextual relevance can be determined. Therefore it becomes necessary to consider not only process- and user-related information, but also location-based, device-related and time information.

Unlike the overall relevance (cf. Figure 1 on page 3), the contextual relevance is not influenced by other quality dimensions. As an example consider again the preparation of the ward round for which the doctor needs the patient record. Let us assume that the patient record is punctually available. In this case the patient record has high contextual relevance and high overall relevance. Let us assume that the patient record is not punctually available. In this case the contextual relevance is still high, but no overall relevance can be identified since the quality dimension punctuality is not fulfilled.

3.2.4 Completeness

The quality dimension *Completeness* (QD4) indicates whether or not all parts of a complex process information (comprising several information parts) are available. In order to perform the activity ”create medical instructions”, for example, different blood values (together representing a process information ”blood values”) must be available. Process information is incomplete if some parts of a process information are missing. It is important to mention that completeness thereby depends on the currently needed information, i.e., it depends on the current work context. Picking up again our example, this does not mean that all possible blood values must be available, but only those being needed for current patient treatment.

3.2.5 Value-Added

The *Value-Added* quality dimension (QD5) indicates whether it is possible to increase some ”value” (e.g., patient satisfaction, diagnostic accuracy) by using process information. For example, information about patient needs is value added because the fulfillment of the needs increases patient satisfaction. The value-added amount is calculated as the difference between the value that can be realized without using specific process information and the value that can be realized with specific process information. Figure 8 shows this relationship. However it is quite difficult to determine the value-added quality dimension since respective effects often cannot be exactly estimated.

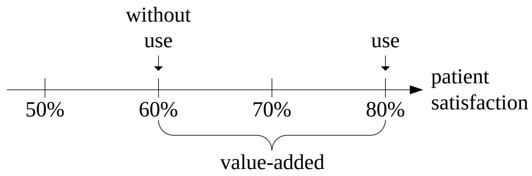

Figure 8: Value-Added of process information.

3.2.6 Appropriate Amount

The quality dimension *Appropriate Amount* (QD6) of process information indicates whether the amount of available process information is sufficient. This is the case if the amount meets the requirements of process participants. For example, a doctor needs the name of the patient and pre-existing diseases. The appropriate amount of process information is not sufficient if he gets the entire patient record. In practice, this problem is solved by extracting process information via software (e.g., a document is divided into individual information objects). In our case studies we analyzed the appropriate amount of process information. Obviously, decision-makers are confronted with too much information. Knowledge-workers, by contrast, have the problem of being confronted with insufficient information.

3.2.7 Granularity

The *Granularity* quality dimension (QD7) indicates whether the aggregation of process information meets the requirements of process users. Process information has the right granularity if immediate use is possible (cf. Figure 9). For example, if a doctor needs to know the average body temperature a patient had during the past week he should immediately get the calculated average value but not the individual values.

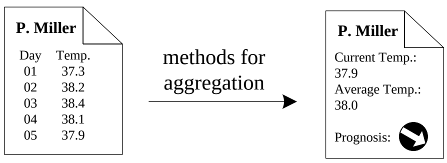

Figure 9: Granularity of process information.

According to [Jun06], three aggregation dimensions need to be distinguished: (a) time dimension, (b) area-specific dimension, and (c) value and quantity dimension. As an example of the time dimensions consider the aggregation based on emergencies per day, month, or year. Examples of the area-specific dimension include aggregation by organization units (e.g., number of patients on ward A) or patients (e.g., patients' age and gender). As an example for the value and quantity dimension consider aggregations relating to cost centers (e.g., research and development, patient service).

Unlike the granularity, the appropriate amount (QD6) meets the requirements if non-aggregated information is provided. Let us assume that the doctor wants to know the average body temperature of a patient. If individual data items are provided, only QD7 meets the requirements. If the average body temperature is provided, both QD6 and QD7 meet the requirements.

3.2.8 Neighbourhood

The *Neighbourhood* quality dimension (QD8) indicates how strong and how frequently process information is linked to other process information. Process information which is strongly and frequently linked tends to be more important. In addition, the semantic of the relation is important. Examples include metadata-matching (e.g., author, keyword), text similarity, and usage-pattern [WM09]. Figure 10 illustrates the relations between process information along a simple example. Starting from a process information (doctor in our example) we can identify the neighbourhood being relevant.

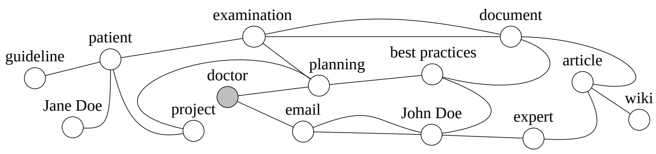

Figure 10: Neighbourhood of process information.

3.2.9 Methods-of-Use

The *Methods-of-Use* quality dimension (QD9) indicates how a process participant uses the process information. Suitable use cases are, for example, to read, create, update, and delete the process information. For example, a process user cannot use read-only process information if he wants to edit process information.

4 Evaluating Quality Dimensions

Quality dimensions are an important means to determine process information quality and the overall relevance of process information for a particular process participant. They are thus also an important means to realize process-oriented information logistics.

Generally, there exist several approaches which can be used to decide whether process information fulfills our defined quality dimensions: (a) *algorithmic methods*, (b) *semantic technologies*, (c) *social methods*, and (d) *convergent methods*. *Algorithmic methods* are, for example, the vector space model, the term frequency algorithm, and methods of clustering. The use of *semantic technologies* is another possibility to determine process information quality (e.g., via ontologies) [WM09]. *Social methods* include collaborative tagging or human-based rating of process information [WZY06]. Finally, *convergent methods* improve the aforementioned methods through their combination (e.g., algorithmic detected relationships between process information are editable by process users). Table 1 illustrates which of these methods can be used to determine our introduced quality dimensions.

Table 1: Methods to determine process information quality.

Shortcut	Quality Dimension	Algorithmic	Semantic	Social
QD1	Punctuality	x		x
QD2	Topicality	x		x
QD3	Contextual Relevance	x	x	x
QD4	Completeness	x	x	x
QD5	Value-Added			x
QD6	Appropriate Amount	x		x
QD7	Granularity	x		x
QD8	Neighbourhood		x	
QD9	Methods-of-Use			x

5 Related Work

Different authors investigate process-oriented information logistics in general. The state-of-the-art regarding information logistics is summarized in [DW09]. Empirical evidence on benefits generated by information logistics concepts is provided in [BD08]. Context-awareness in particular is discussed by Haselhoff [Has05] and Meisen et. al [MPVW05]. Problems of data quality and solutions for data quality improvements are described in [Red01]. Scannapieco et. Al [SVM^{+}04] present an architecture for managing data quality in cooperative information system.

Quality dimensions of information in general have been considered in literature. Jung [Jun06], for example, investigates data integration architectures and also sketches quality dimensions. Wang et. al [WW96, Wan98] identify aspects of data quality based on empirical research and integrate their findings into a data quality framework. Naumann et. al [NLF99] describe a framework for multidatabase query processing taking information quality into consideration. Table 2 compares our quality dimensions with the ones in the aforementioned papers.

Table 2: Contextual Quality Dimensions from different viewpoints.

Shortcut	Quality Dimension	Our Paper	Jung [Jun06]	Wang [PLW02]	Naumann [NLF99]
QD1	Punctuality	x	x	x	x
QD2	Topicality	x	x	x	x
QD3	Contextual Relevance	x			
QD4	Completeness	x	x	x	x
QD5	Value-Added	x		x	
QD6	Appropriate Amount	x	x	x	x
QD7	Granularity	x	x		
QD8	Neighbourhood	x			
QD9	Methods-of-Use	x	x		
*	Relevance		x	x	x
*	Periodicity		x		
*	Price				x

Wang subsume QD1 and QD2 under the term *timeliness*. In our paper, *relevance* is not a separate quality dimension. Rather, relevance results from the combination of all quality dimensions. Our QD3 is not influenced by other quality dimensions (cf. Section 3.2.3 on page 7). According to Jung, the relevance can be affected by other quality dimensions (e.g., by QD1). In the paper of Wang, the influence towards the relevance is unclear. Wang et. al [PLW02] define relevance as ”the extent to which information is applicable and helpful for the task at hand”. Jung subsumed QD4 and QD6 under the term *completeness*. In our research the quality dimension *periodicity* is based on the information sources and is therefore not a quality dimension of process information. The quality dimension *price* can be omitted because commercial data providers are not in focus. Naumann closely follows Wang. Due to different perspectives some quality dimensions of Wang (e.g., value-added) are omitted in the paper of Naumann.

6 Summary and Outlook

Enterprises are confronted with a continuously increasing data overload making it difficult for them to provide the needed information to their employees. Thereby, relevant information is often closely related to the execution of business processes. Hence, the main problem is to identify information being relevant for a process user and his activities in a given work context. To solve this problem, enterprises crave for an intelligent and process-oriented information logistics enabling them to provide the right process information, in the right format and level of granularity, at the right place and accurate point of time to the right people. To realize such process-oriented information logistics, quality dimensions of process information adopt a key role. This paper picks up this issue and investigates quality dimensions and discusses their role for process-oriented information logistics.

Future research includes an evaluation of the proposed contextual quality dimensions with respect to the development of an intelligent, process-oriented information logistics. We will investigate the factors determining the work context of process users. Only a precise understanding of a work context allows us to accurately determine the overall relevance of process information. Future research will also pick up again Table 1 and will address the application of the discussed methods to determine our dimensions in detail.

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