

# Selecting appropriate tools for synchronous communication and collaboration in locally distributed product development

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## **Abstract**

Following progress in information and communication technology (ICT) on the one hand and considering the potentials of global markets on the other hand not only production facilities are distributed worldwide. Product development processes themselves are distributed among different locations and across borders. Thereby the need for media-based synchronous communication in product development increases continuously. At the same time virtual teams in product development and their communication demands face a great number of available collaboration tools.

Findings based on media richness theory and media synchronicity theory state that these tools should be selected according to the requirements of the given task. However these recommendations tend to be too unspecific for the differentiation of available and sometimes very similar tools. Moreover, intuitive usage might be difficult for most product developers. Additionally these theories don't satisfy specific characteristics of product development like different types of data (e.g. texts, sketches, FE models) and important methods (e.g. creativity methods).

The presented paper addresses the question of how product development in virtual teams can be supported in the selection of media for synchronous communication and collaboration. First a model which describes types of situations by activities and characterizes tools by features is developed. Secondly, these aspects are systematically connected. Additional elements of the model refer amongst others to the possibility of combining different tools or the resources tools occupy. Based on the model methods for the selection of tools both on a strategic and an operational level are proposed. Furthermore as a first evaluation and to gain information for further development of the model a laboratory study was performed with 16 participants in small groups carrying out creativity methods by using software tools selected out of approximately 35 tools. Overall the chosen approach seems useful. Nonetheless further research is necessary to select appropriate tools for conducting specific methods of product development in virtual teams.

***Keywords: product development, virtual teams, selection of tools, communication, collaboration***

# 1 Introduction and Motivation

Besides the internationalization of global markets and value chains also an increasing amount of product development activities are organized across locations and borders (Zanker and Horvat, 2015). This evolution of product development is enabled by huge progresses in information and communication technology on the one hand but makes great demands on the embodiment of future information and communication technologies on the other hand.

In this context existing media and software solutions support primarily the communication processes itself as well as the presentation of existing information, e.g. based on text documents or presentation slides shared by desktop sharing. Functions which support activities regarding the common creation of information or the assessment of different solution options are implemented less often. But these activities play an essential role for product development and are often accompanied by specific data types like sketches, CAD models or FEM models which even intensify the demand on specific functions provided by software solutions.

As existing tools are rarely developed to meet the specific demands of locally distributed product development teams these teams and their companies must choose their software solutions consisting of one or more tools from a huge number of tools with a focus which is not specific for product development.

This selection of tools for locally distributed product development teams is not supported in an adequate manner at the moment. Additionally operational and strategic targets must be taken into account in this context.

## 2 State of the Art

### 2.1 Common theories for the selection of media

To describe the task of selecting adequate media for specific communication situations and contexts several theories of media selection have been developed. Most of them act on the assumption that “selecting media is the result of a cognitive evaluation of comparing characteristics of media types with those of given communication situations” (Riemer and Filius, 2009). They differ mostly in the question which characteristics of media and communication situation is estimated as relevant or more relevant respectively. The media richness theory as one of the earliest examples of a theory for media selection focusses on the comparison of richness of information that shall be transmitted and the richness of communication media. In this context “information richness is defined as the ability of information to change understanding within a time interval” (Daft and Lengel, 1986). In contrast the richness of media is being understood as its suitability to reduce ambiguity and misunderstanding. Concerning richness (Daft and Lengel, 1984) differentiate these media in decreasing order: Personal conversation, phone call, personal documents (e.g. mails), impersonal documents, numeric documents. The media richness theory suggests to match the richness of information to be transmitted and the richness of communication media as well as possible because a communication media which is too weak in richness leads to misunderstanding. A communication media which is too strong in richness on the other hand could lead to inefficiencies.

Based on the finding that the concept of richness of communication media is too abstract and includes some characteristics of communication media Dennis and Valacich developed the media synchronicity theory which can be seen as refinement of the media richness theory (Dennis and Valacich, 1999). The authors define five essential attribute categories:

- immediacy of feedback (the ability to bidirectionally and immediately enable communication)
- symbol variety (the number of ways in which information can be communicated)

- parallelism (the number of potentially parallel conversations)
- rehearsability (the possibility to edit information content before sending it)
- reprocessability (the recoverability of information for a conversation)

Additionally they assign a value (low, medium, high) to every communication media in each of these categories. The media synchronicity theory suggests to select the most suitable communication for each situation according to these five dimensions. Due to the fact that these five categories contribute to richness defined by media richness theory but none of the media has the highest value in all of the five dimensions (personal conversation is for example higher in immediacy of feedback compared to E-Mail, but lower in rehearsability) richness in a strict sense doesn't even exist. Moreover, there exist serious differences in the implementation of a communication tool like different email programmes.

## **2.2 Best Practices**

Unlike the holistic concepts of the theories described in the previous section experience based guidelines for the selection and the use of media in practice often provide much more specific recommendations. Although this advice sometimes match theoretic concepts they usually refer only to single use-cases or tools: For example bad news or sensitive issues should not be communicated via e-mail, phone conferences should be preferred for conflict situations (Stöger and Thomas, 2007). Processes for solving a problem which require creativity or decision making should be conducted with audio-visual or audio-based conversation at least (Leitner and Tuppinger, 2004) whereas audio-based communication is usually more efficient than text-based communication, video conferences are not necessarily more efficient than phone conversations and video is often mostly used due to better awareness (Stöger and Thomas 2007).

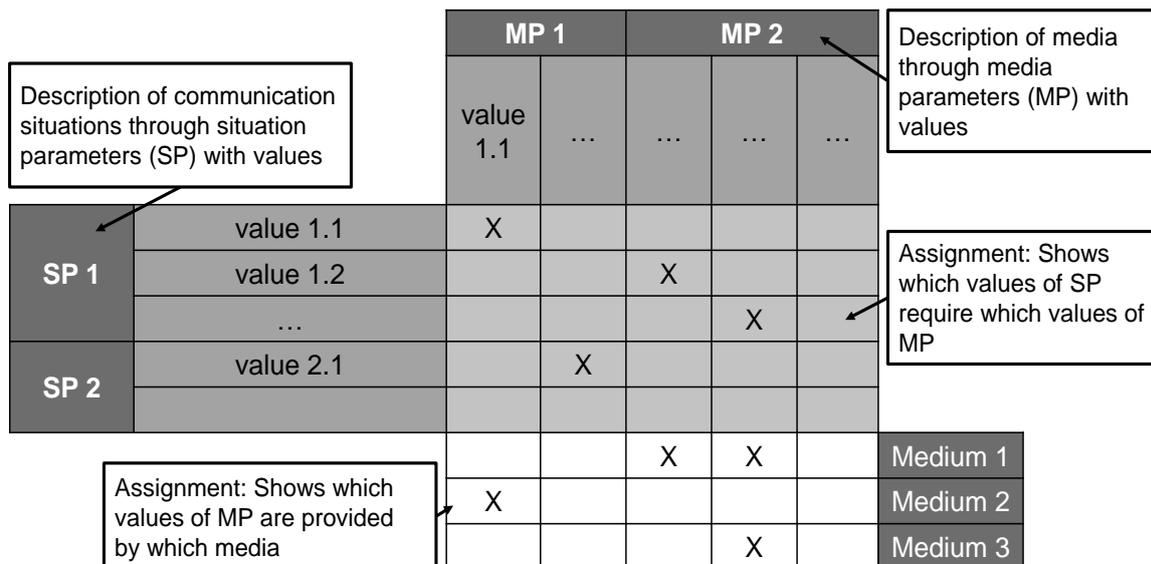
A possibility of structuring and summarizing those experience-based recommendations is a media plan – basically a simple table with two columns listing (standard) situations of media-based communication in the first column and in the second one the tools that should be used in each situation.

## **2.3 Media model of Grieb**

The media model of Grieb is one of the few approaches which aim at the selection of communication media and tools in the context of product development (Grieb, 2007). The model is based on previous approaches which were less suitable for practical implementation. Communication situations are described by situation parameters (e.g. number of participants). In line with that media types are characterized by media parameters. Based on this the values of situation parameters (e.g. “two participants” or “small group”) and the values of media parameters (e.g. “absolutely reliable” or “not reliable in all situations”) are linked. An existing link means that a situation parameter requires a media parameter as shown in Figure 1.

The collection of situation and media parameters provided by the author is based on different literature sources as well as own research and claims to be as complete as possible.

For a situation specific selection of media it is sufficient to determine the situation parameters (e.g. through a check list). Through the links in the model the user can identify suitable media or even suitable combinations of media which provide the media parameters required by the situation parameters of the actual situation. Though this approach meets some of the specific demands of the product development context it does not distinguish between media choice on the strategic and the operational level and filling a checklist with about 20 situation parameters might still be too much for often occurring situations.



**Figure 1: Media model of (Grieb, 2007) (simplified)**

## 2.4 Specific characteristics of communication and collaboration in product development teams

An essential part of communication situations which a suitable communication tool shall be selected for is the type of information being transmitted. These information types are very manifold in product development. In product development processes the created information appears in different kinds of data types and information formats like texts, sketches, drawings, bills of material, CAD models or physical models which represent different degrees of concretion (Krause, 2001). If for example an information represented in a CAD model shall be discussed about in a situation of synchronous communication in a virtual team the problem arises how to point on a certain spot in this model in order to put awareness of communication partners to it. As soon as it comes to the editing of this model there exist almost no suitable functionality in relevant tools used in product development.

An important fact which is specific for product development is the narrow link between data types, information formats and methods of product development. The inclusion of functionalities into communication tools which support specific methods of product development can be seen as a critical factor for virtual teams in product development. These functionalities are not implemented in communication tools which hinders the selection of suitable communication tools for virtual teams in product development additionally.

## 3 Need for research

Based on its potential advantages locally distributed product development becomes increasingly important. Globalization, intensified competition and shorter product life cycles force the introduction and spreading of locally distributed product development in companies (Schmalzl, 2004). Teams with a great degree of virtuality are used more and more frequently (Hertel, 2007). Thus the need to cross geographical – and by that also time and cultural – distances, especially with tools for synchronous communication and collaboration, grows continuously (Gilsa et al., 2004). This poses different problems which are not only caused by the media as such but by the wrong use of media as well as the use of wrong media (Stöger and Thomas, 2007) and therefore bad selection decisions. At the same time the wide range of available media becomes even wider (Ehrlenspiel and Meerkamm, 2013). While the need for a method to support the selection of media in locally distributed product development is therefore obvious, Table 1 shows that none of the existing approaches can cover the corresponding requirements. The criteria listed in Table 1 result from different sources.

Intuitive use, expendability and small effort for daily use are obvious criteria. The differentiation between different levels such as operational and strategical, are common for company structures (cf. e.g. (Kern, 2005)) and has yet been transferred to media choice as well (e.g. by (Herrmann et al., 2012)). Finally further criteria result from considering characteristics of product development (cf. section 2.4) in the context of product development within virtual teams.

**Table 1: Estimating the extent to which existing approaches and concepts fulfil the requirements for methods supporting media selection in locally distributed product development (“+” = good, “o” = moderate, “-“ = bad).**

Requirements for methods supporting media selection for virtual teams in product development	Theoretical concepts	Best practices/ media plan	Media model (Grieb 2007)
Differentiation between strategic and operational level of media selection, including the assignment of different determining factors and boundary conditions	-	-	-
Intuitive use for product developers	-	+	o
Required effort for use appropriate to the situation, especially on the operational level	o	+	o
Suitable for choosing from the wide range of available media while differentiating similar media sufficiently	o	o	o
Expandable for integration of future media	o	-	+
Considering the different types of data that is worked with in product development	o	-	+
Foundation for transferring methods of integrated product development to virtuality	o	-	o

## 4 Research Methodology

Based on literature research on a) use-cases of synchronous communication and collaboration in locally distributed product development and b) available communication tools a generic model is derived to display the different influencing factors on media selection processes and the connections and dependencies between these factors. Using the obtained model methods to select appropriate tools both on a strategic and an operational level of locally distributed product development are suggested. Besides this a generic approach instead of adapting current information on synchronous communication and collaboration processes and related media selection is used for a number of reasons. First, relying on information on existing processes would require those processes to be performed in an adequate way. Various problems indicate that this cannot be assumed. Moreover, a generic approach facilitates the adaption for different enterprises with their individual operational and organisational structure. In general, a ‘tool for synchronous communication and collaboration’ can be understood as a term of wide comprehension including not only telephone-, video-conferencing-systems and software but also different interface devices which can be useful for the considered interaction processes. The model presented below is primarily designed regarding telephone, video and web conferencing tools for synchronous communication and collaboration, though.

## 5 A model for the selection of tools on strategic and operational level

### 5.1 Model for the selection of tools

The basic principle of each systematic approach for the selection of media is matching the description of a situation with the characteristics of available tools. The tool or combination of tools which fit the requirements of the situation best is chosen.

In this context the description of situations of synchronous communication and collaboration in locally distributed product development is based on the assumption that those situations consist of different activities which are carried out during the situation. To describe an activity in more detail we used the same definition as the integrated product development model is based on (Albers and Braun, 2011): An activity is comprised of an action, an executing resource, a usable resource and a chronological connection. Looking at methods such as creativity methods that are already used for communication and collaboration in product development (Albers et al., 2014) while also regarding the different types of data allowed to derive a first set of generic actions (cf. Table 2) which was specified in numerous steps. In addition to the actions the situations are also described by characteristics of the group of participants.

**Table 2: Initially in the model included sets of actions, characteristics of groups of participants and features of tools.**

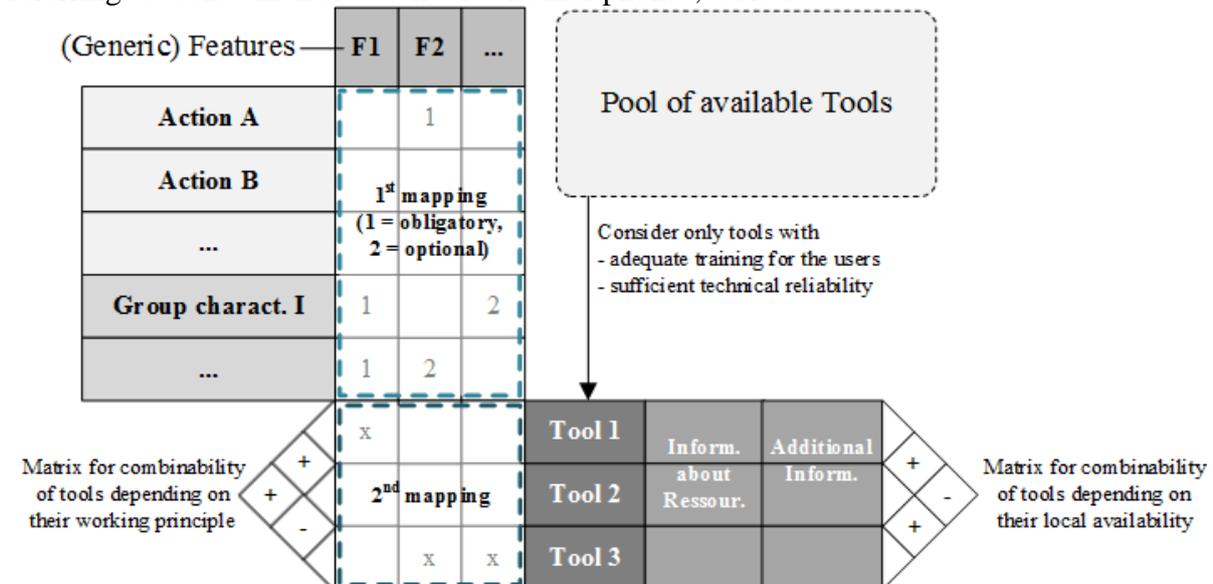
Actions		
Presenting electronic stored content	Collecting text items	Deciding / choosing / Voting for something
Creating / editing text together	Collecting sketches	Making a poll among themselves
Informal conversation	Evaluating different alternatives	Creating / editing a sketch together
Conducting a moderated talk	Presenting physical objects / not electronic stored content	Creating / editing a table together
Coordinate simultaneously to the main conversation by some participants		
Characteristics of the group of participants		
Low degree of familiarity		(Very) different kind of expertise
Features		
Enable text-based conversation	Enable video-recording objects at far distance	Enable polls (free answers)
Enable audio-based conversation	Enable video-recording from different angles of view	Enable votings (yes/ no/ abstention)
Enable audio-visual conversation	Enable watching text together (somehow or other)	Provide (simple) numeric evaluation tool
Enable more than one communication at a time	Support watching collected text items together (somehow or other)	Support file exchange
Display availability of potential participants	Enable watching a sketch together (somehow or other)	Enable alternating editing of electronic stored content by different participants
Allow for flexible number of participants (joining / leaving during situation)	Support watching collected sketches together (somehow or other)	Enable simultaneous editing of sketches by different participants
Support moderation of a conversation	Support awareness	Enable simultaneous editing of texts by different participants
Enable anonymity of participants	Enable annotations visible for all participants	Enable simultaneous editing of tables by different participants
Enable viewing electronic stored content together	Support collecting text items	Support process documentation
Enable video-recording objects at low distance	Support collecting sketches	Support result documentation

„Usable resources“ in situations of synchronous communication and collaboration are the used media. In the presented approach they are described by generic features. An advantage of doing so is that the users of tools – product developers – and tool designers have at least an similar maybe even common understanding of features as a purpose of a technical system. Like for the actions a first set of features can be defined and has to be modified and expanded based on user experiences. To match the description of situations by actions and characteristics of the group of participants and the description of tools by features a matrix is used (cf. „1<sup>st</sup> mapping“ in Figure 2). This first mapping links actions and characteristics of the group of participants with the features they require. The assignment distinguishes if a certain feature is obligatory or optional for a certain action or characteristic of the group of participant. For example the presentation of electronically stored content by one of the participants requires features for audio-based conversation and for watching electronically

stored content together while additional support of awareness, enabling annotations and file exchange are judged to be optional.

A second mapping displays which features each tool provides. Out of the pool of available tools only those tools may be considered which work properly to a minimum extent due to the availability of adequate training for users and sufficient technical reliability. For the first version of the model approx. 35 different tools were evaluated (software, phone- and video-systems).

As a single tool often doesn't match all requirements of a situation the combination of tools is an important issue. There are several influencing factors that determine the combinability of tools and which are thus represented in the model. Two important aspects are the local availability and the working principle. Tools which are not available in the same place are naturally not combinable as well as tools whose working principles are not compatible. To store the according information in the model two consistency matrices are added. Analogously to the roof of the house of quality they enable in each case a binary relation between all the tools in the model. In this way by using "+" and "-" in the fields of the matrices, the combinability of tools is displayed. Yet, three different "places" are distinguished: The personal desk of an individual user, conference rooms allowing several persons at one facility to meet and to connect with people from other facilities and "mobile" referring to tools which are available on smartphones, tablets etc..



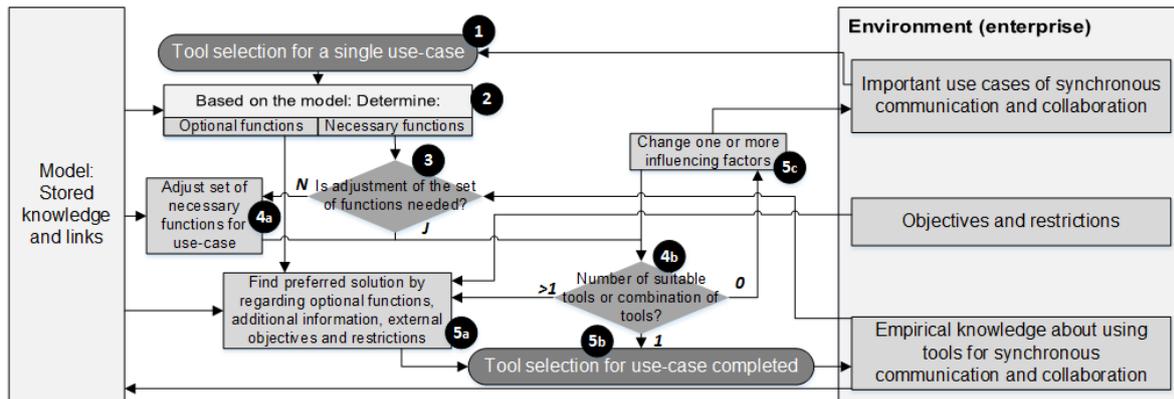
**Figure 2: Model for selecting media for situations of synchronous communication and collaboration in locally distributed product development**

Another factor which determines the combinability of tools which are according combinable to the two previous aspects is the extent to which each tool demands available resources. For example one cannot use two software solutions in combination at the same time if they each need a full screen for proper use and the user has only one screen. An extra column of the model covers this aspect of resources. Finally, motivated by thinking of the tool selection process as an optimizing process which needs optimization criteria as long as there is more than one possible solution another column includes additional information, e.g. cost of use, that can be used as such criteria.

## 5.2 Selection of tools

### 5.2.1 Strategic level

Before using the model for the selection of tools it can already support an analysis of the current situation. One can investigate existing problems and narrow down potential causes, e.g. missing functions which are not provided by used tools, network problems which affect the use of tools that provide all functions needed or insufficient competence of the people using the tools. The method itself for selecting tools on the strategic level is displayed in Figure 3.



**Figure 3: Selection of tools on a strategic level, based on important use-cases. Has to be done for multiple essential use-cases. Sequence of steps (e.g. whether 3→4a or 3→4b) depends sometimes on the answer to given questions**

It is assumed that on a strategic level the process of selecting tools for synchronous communication and collaboration is seldom and has far-reaching consequences at the same time. Hence, a potentially big effort is eligible. The selection process is based on information on important situations which the tools are meant to be used in. Important situations are either such occurring very often in daily business or such which may occur less often but are of major relevance, e.g. milestone meetings. The selection of a tool or a combination of tools is done individually for each type of situation. Usually the individual selection processes are interdependent, though. The first step for each considered use-case is the specification of the included actions and – as far as this is already possible on this level – the characteristics of the (potential) group of participants. Following this analysis the model provides a list of functions which are either required or optional for the use-case.

### 5.2.2 Operational level

For important situations of synchronous communication and collaboration creating a media plan is suggested. Important situations are those which were used as a reference for the selection of tools on the strategic level. Therefore already existing data and information used in the selection of tools on the strategic level can be utilized for building the media plan.

Selecting media for exceptional situations of synchronous communication and collaboration which are not included in the media plan has to be done in another way, hence. Using the same procedure as on the strategic level must be assumed to be too complex and time consuming for a single situation. Nonetheless the presented model provides helpful support: first, the basic idea of the model starting with actions and the group of participants, following necessary and optional functions and ending with appropriate tools serves as a guideline for the selection process. Secondary, knowledge stored in the model (e.g. links, additional information) is used for carrying out the different steps of the selection process successfully.

## 6 Discussion and Outlook

The core structure of the presented model is similar to the work of Grieb although the approach for describing situations and tools differs. Additional elements allow to display influencing factors which are important boundary conditions for the selection process, but not associated directly with the extent to which an individual tool fulfils the requirements of a specific situation separately. The suggested, model-based method for tool-selection take the difference between the strategic and the operational level into account. This can especially reduce the necessary effort for tool selection in daily business.

To proof this usability and confirm the suitability for eliminating the weaknesses of existing approaches summarized in section 2 an evaluation is necessary. A first use of the approach in a laboratory study with 16 participants to choose appropriate tools for performing creativity methods in virtual teams in product development has been successful, though (Walter et al., 2016). A laboratory study allowed for good control of the environment while at the same time testing and establishing this cost-efficient research method in the given context of product development with virtual teams. One result was that not only the availability of a feature is important but the way it is implemented where additionally the judgment of an implementation might depend on the use-case it is used in. But, as a consequence of using a laboratory study transferability of the results to real settings might not be unlimited and not all aspects of real environments can be reproduced in laboratory studies.

On the operational level it can be assumed that the media-plan-based concept will work properly as it refers to an already proven approach. Along with the evaluation and use of the presented methods the model, in particular the actions in situations of synchronous communication and collaboration in product development, the characteristics of the group of participants, the generic features and the linkage of those elements need to be adjusted and extended, if necessary. Concerning the implementation of features, the different ways in which different tools implement features and the effect of this various implementations on the suitability of tools probably needs more consideration.

As there exist already numerous tools of communication and collaboration which are complemented continuously the tool section of the model must be understood as work in progress making it necessary to review new tools on the market constantly. Although the usage of the presented approach of tool selection for synchronous communication and collaboration has been evaluated in the context of a laboratory study there remains the challenge to validate it in a practical context.

Another challenge is to strengthen the connection of actions and methods of product development used for this purpose in the model as the execution of a method like a creativity method brings its own requirements.

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