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A Conceptual Foundation for the Shannon-Weaver Model of Communication

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Abstract: An understanding of communication systems directly impacts all facets of life including human and technology interactions. Models based on the Shannon and Weaver Data Transmission Model are the most commonly used communication models at the technical level and have been used extensively in other fields of study as well. This study is a contribution to the development of a communication model based on a foundation adequate for a broad information handling context. A new conceptual representation is applied to Shannon-Weaver Based Models to supplement current understanding of some of the fundamental concepts employed in that model. The intentions are to narrow the gap with other communication models and to promote a unified approach to study of the field.

Key words: Communication, message, signal, content, communication model, Shannon and Weaver Data Transmission Model, Westley and MacLean Model

INTRODUCTION

It is often said that we are living in the information age when computers and network technologies have made it possible to overcome the limitations of time and space imposed on communications. Communication now has greater speed, larger capacity, more flexibility and new varieties of messages. We are at the brink of still another new era the communication age. Why? because perceived bandwidth is becoming virtually free (Thornburg, 1995).

Communication phenomena have been a central means of major transformations in the world. When it first appeared, the telegraph was described as an instrument of the age of instant global communications (Estabrooks, 1995). In the 20th century, Early Bird, the world's first commercial satellite was the start of a massive global communication revolution in the 1960s (Alberts *et al.*, 1997). Current digital transmission technologies have had a significant impact on human interaction and hold promise to further increase humankind's ability to overcome constraints on communication imposed by time, location and distance (Alberts *et al.*, 1997).

Additionally, communication by its very nature and in its various forms coincides with many important issues such as privacy, security, authenticity, efficiency, distortion and so forth.

Consequently, understanding communication is important because it directly impacts all facets of life including human and technology interactions and control. Communication includes all aspects involved in the creation, export, import and processing of artefacts used to link objects in the world. The study of communication encompasses all features of a communication system including its technical, personal, social and organizational forms. Models are important tools for studying communication (Adetan, 2007).

A model is a systematic representation of an object or event in idealized and abstract form. The act of abstracting eliminates certain details to focus on essential factors (Mortensen, 1972).

In communication, a model provides a framework for discussion of problems in the communication process. A good communication model clarifies and simplifies the structure of communication and offers new insights into what can only be described (Mortensen, 1972).

Models based on the Shannon-Weaver Data Transmission Model (Shannon and Weaver, 1949) are the most commonly used communication models at the technical level. Within a decade a host of other disciplines many in the behavioral sciences adapted it to countless interpersonal situations, often distorting it or making exaggerated claims for its use (Mortensen, 1972). According to Sperber and Wilson (1986) while Shannon and Weaver's diagram is inspired telecommunications technology, the basic idea is quite old and was originally proposed as an account of verbal communication. Nevertheless, Shannon and Weaver's Model has been criticized in regard to several aspects.

The model is not really a model of communication, however. It is instead, a model of the flow of information through a medium and an incomplete and biased model (to technical media). The model suggests that communication within a medium is frequently direct and unidirectional but in the real world of media, communication is almost never unidirectional and is often indirect. In addition, Kaminski enumerates various weaknesses in the model:

- Not analogous to much of human communication
- Only formal does not account for content
- Static and linear

This study is a contribution to the development of a communication model based on a foundation adequate for a broad information handling context. A new conceptual representation is applied to Shannon Weaver Based Models to supplement current understanding of some of the fundamental concepts employed in that model with the aim of narrowing the gap with other communication models and promoting development of a unified approach to the study of the field.

Problem

Methods of representation: This study addresses a new method of representing the communication process in diagrams. The method is applied to different models. According to Blackburn (2007):

> It would be at best naive to regard that model (of communication) as the only model available. Indeed as Berge points out, communication-relevant literature demonstrates the existence of several models. This is evident even though the adherents to various models do not always directly or explicitly refer to those models. As Berge states it: the trends (in communication relevant research) can be classified according to the basic models of communication they have adopted

This study emphasizes the conceptual representation of different models, starting with the Shannon-Weaver Model. In this study we discuss examples of these representations and their weaknesses in order to show specific motivations for the approach. In the next part, we present this as a flow based representation.

Flensburg (2009) examines the communication model as it relates to the problem of transferring knowledge between humans:

> The model provides a vocabulary for discussing certain issues about communication and is thus more like a tool for the scientist than for use in for instance practical systems development. The strength of the framework is the identification of several similar steps in the communication process which can be treated in a rather coherent way

Flensburg starts with the Shannon-Weaver Communication-System Model (Fig. 1) which he considers a model of signal processing. Clearly the transmitter transforms the message into signal but then the exact conceptual relationship between them is not clear. Similarly, receiver transforms signal into message. The following is an example of a conceptual treatment of this issue.

Flensburg (2009) tries to use the notions of format and structure to determine the relationships among bitstream, data and information. The following discussion suggests the difficulty in understanding the representation of different relationships with no implication of their correctness. According to Flensburg (2009):

> Anyone who has dealt with data transmission knows that you have to know something about the format and type of data that are to be transferred. First you have to know if it is data or a program

If it is data you transfer, you must know something about the type (text, picture, audio, video or something else). For each type you must know exactly what type it is. The sender and the receiver must also have the same format short: Bitstream + Format = Data (Fig. 2).

Flensburg then moves to the notion of structure and the catchphrase: Structure + Data = Information. Seeking to understand these relationships in Fig. 2 makes the issue difficult. The arrow from Data to Bitstream may indicate transformation but the semantics of the arrow from Format are mysterious. The arrow may indicate that the transformation from data to Bitstream is performed according to a format but from the conceptual

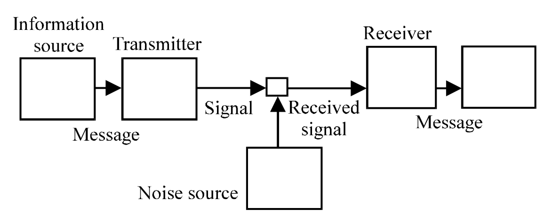

Fig. 1: Schematic diagram of the Shannon-Weaver Model

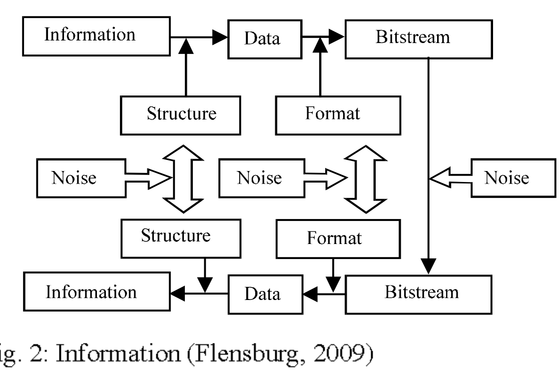

Fig. 2: Information (Flensburg, 2009)

point of view such a meaning cannot be denoted by the same symbol (a solid arrow). The broad arrows clearly represent flow in the channel but why do these arrows connect structures and formats? Maybe this indicates flows from the upper portion to the lower portion of the figure. How about the arrow between bitstreams?

We raise these points to claim that these symptoms of weakness in a conceptualization of the notion of communication are shared with most other communication representations.

Lenski (2010) tries to understand information to characterize the kind of relationship between knowledge and information:

> Mere changes in an interior configuration caused by some form of input do not qualify as information. There must be more. Does a computer get informed by my typesetting? Developing a conceptual understanding involves a communication setting

Lenski (2010) understands the relationship between knowledge and information in terms of the channel shown in Fig. 3.

> Handling information is clearly different from experiencing the world. Another consequence of the distinction between knowledge and information therefore, concerns the nature of the exchange between the two cognitive systems. The question arises of what is exchanged or in other words, what is the material that is informed. It is common understanding that this material is denoted as data

Lenski (2010) concludes that information and knowledge are conceptually the same: information is a communicated knowledge. It is some sort of external knowledge that is only available in the form of data (Lenski, 2010). Conceptually, Fig. 3 suffers from weaknesses similar to those identified in Flensburg (2009)'s Model.

This discussion certainly does not give Flensburg (2009)'s and Lenski (2010)'s models a fair treatment however, the purpose of the discussion is to illustrate the types of representation used in these models and their weaknesses. We claim that the diagrammatic representation is precise and more coherent in characterizing any communication system.

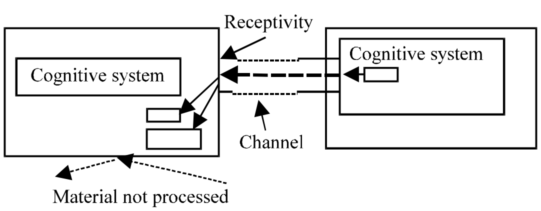

Fig. 3: The context of information (Lenski, 2010)

In fact, the criticism can be applied to the schematic diagram of the Shannon-Weaver Model (Fig. 1). The message flows from the source to the transmitter and the signal flows from the transmitter to the channel. If these are different things, why are their flows represented by the same type of arrow? Conceptually this is analogous to representing electric and water in a technical diagram with the same type of arrow. According to Schroeder (2011):

> Shannon's information theory has been criticized by the researchers of attempts to develop semantic theories of information but these attempts have been no more successful in developing semantics of information, nor in formulation of adequate theory of information, than the orthodox approach

MATERIALS AND METHODS

Flowthing Model: The Flowthing Model (FM) represents communication on the basis of two fundamental notions:

- A flow that represents the conceptual movement of flowthings
- A triggering that represents the start of a new thing, e.g., another flow, an operation (Al-Fedaghi, 2005, 2008, 2010, 2011, 2012)

Flowthings are things that can be transferred, released and created, arrive, be accepted and be processed by flow systems (flowsystems) including things such as data information, knowledge, signals, bitstreams and so forth. In the context of communication, flowthings are things that are being communicated. The stages of the flowsystem comprise creation, release, transfer, arrival, acceptance and processing. A complete flowsystem is shown in Fig. 4. The environment of the flowsystem is called its sphere. For example in the sphere of a retailer, we can observe the flowsystems of orders

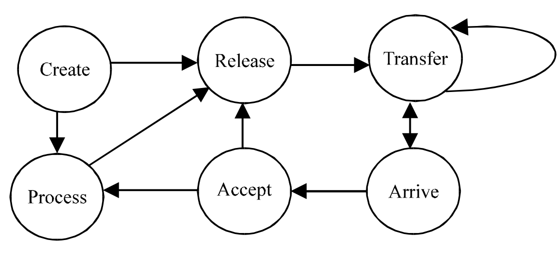

Fig. 4: Flowsystem, assuming that no released flowthing is returned

information invoices and even physical items. In the context of communication, a sphere can be considered to encompass the communicating agents. Whenever arriving flowthings are always accepted, the stages Arrive and Accept are represented by a single stage called Receive. The logical sequence of different stages is important. Any flowthing (e.g., e-mail) cannot be transferred before being released. A flowthing can be released without being transferred as in the situation of a failure in the channel; thus the released flowthings are queued, waiting for the channel to be fixed. Clearly, a released flowthing cannot arrive (e.g., at another sphere) without first being transferred.

The transfer stage represents the input/output component of the flowsystem. It is the interface of the flowsystem with the outside. Suppose we have two spheres:a producer and a consumer. The producer creates, releases and transfers (ships) products in the consumer's sphere, the product has been transferred (to the consumer's input component), arrives is accepted and is processed (consumed).

It is possible that a flowthing enters the transfer stage of a sphere but it never arrives. A byte (string of bits) may actually reach the port (the connection) of a device but for some reason (a fault between the port and buffer), it fails to arrive at the arrival place (e.g., buffer). A newspaper is transferred to the house lawn but it may never arrive in the hands of the house resident. Nevertheless, upon arrival it may be rejected or accepted. So, the flowthing arrives only after being transferred and is processed only after being accepted.

A released, transferred, arrived, accepted and processed flowthing cannot be in the created state. An already flowing thing cannot be considered a newly created thing.

Example: Yates presents a model of interactional communication shown in Fig. 5. From the FM perspective (Fig. 6), the situation includes two spheres: Agent 1 and 2 where each contains two flowsystems: meaning and code. Agent 1 creates (generates) meaning that triggers the creation of code. The code is released and transferred to the code flowsystem of Agent 2. Agent 2 receives the code and this triggers the creation of meaning. The meaning in Agent 2's sphere triggers the creation of code that is released and transferred to Agent 2's sphere.

Example: Blackburn (2007) presents Saussure's (verbal) Model of communication in terms of the diagram shown in Fig. 7. From the FM point of view, it includes two spheres, each with two subspheres: mental

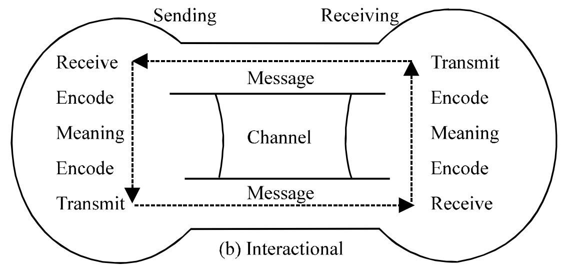

Fig. 5: Communication models

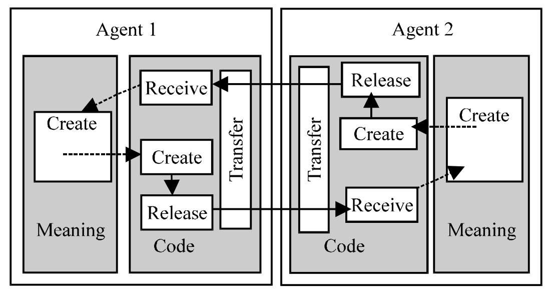

Fig. 6: FM representation of the communication system in Fig. 5

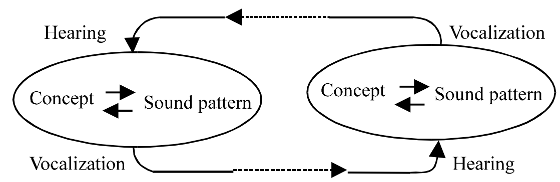

Fig. 7: Saussure's schematic of the speech circuit (Blackburn, 2007)

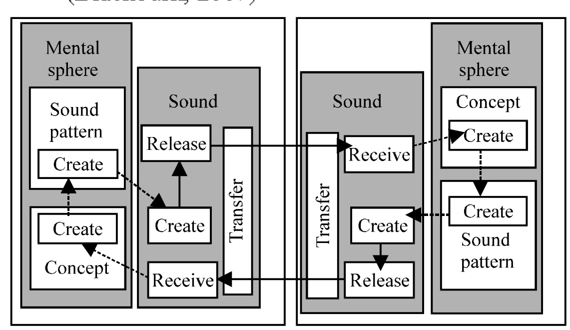

Fig. 8: FM representation of Saussure's schematic of the speech circuit in Fig. 7

and sound as shown in Fig. 8. The mental sphere includes two flowsystems: concept and sound pattern. The (physical) sound includes one flowsystem. For the sake of simplicity, here we use the same name (and box) for both the sphere and the flowsystem of sound pattern.

FM-based communication model: Shannon's original communication model limits the interest to signalling systems (Abel and Trevors, 2005) that include transmitter, receiver, channel and noise. The transmitter prepares the signal for efficient transmission. The channel is the media through which the signal travels from the transmitter to the receiver. The receiver reprocesses the signal and converts the signal to its original form.

All models of communication involve at least three components: source, message (signal) and receptor. The first and third of the components are simply units capable of participating in communication. The second component is that thing which may happen or pass between them (Blackburn, 2007). According to NPTEL:

> We are all immersed in a sea of signals. All of us from the smallest living unit, a cell, to the most complex living organism (humans) are all the time receiving signals and processing them. Survival of any living organism depends on processing the signals appropriately. What is signal? To define this precisely is a difficult task. Anything which carries information is a signal

This is typically stated as a signal carries a message (information, data). To be neutral with respect to different interpretations, we call the signal a carrier and its message (what is carried), a content. There is the possibility that a carrier contains a subcarrier in this case we reserve the term content for things that do not carry anything for the purpose of communication. Carrying is a communication-oriented notion.

The basic features that differentiate carriers and content have fascinated many researchers in the communication area. For example according to Reddy (1979). The whole point of the system is that the alternatives (messages) themselves are not mobile and cannot be sent, whereas the energy patterns, the signals are mobile. Blackburn (2007) insists that messages are not mobile while the signal is mobile. Notice that a flowthing is conceptually mobile since it flows. But conceptual flow is different from physical movement from one place to another. It is possible that flows occur in the same physical place because the two involved stages are physically in the same place (a process that creates). Or it is possible that flows between stages occur simultaneously. For example, if arriving flowthings are immediately accepted, the arrival precedes acceptance logically (i.e., anything accepted in the flowsystem must have arrived previously) but arrival physically coincides with acceptance. Nevertheless, conceptual flow may involve physical movement.

The important point here is that content is a flowthing in the sphere of a carrier. Conceptually, content can be received (i.e., mounted), released (i.e., stepped down from) and transferred from and to the carrier and it is a flowthing in the carrier sphere. A carrier as a flowthing may create or process a content, e.g., a signal (as a flowthing) traveling in a channel may get loaded with noise. Here, creation in the FM model indicates the appearance in the communication process of a new flowthing (a carrier fertilized with noise). Next we discuss the issue of carriers without content in the Shannon-Weaver Model.

Flow Based Shannon Weaver Model: According to Reddy (1979):

> The messages are not contained in the signals. The whole notion of information as the power to make selections rules out the idea that signals contain the message

Nevertheless, conceptually, the content is embedded in the carrier. From the conceptual point of view, the carrier carries the content; otherwise, it is meaningless to have a signal with no content. Figure 9 shows the FM representation of this concept. Note that the carrier denotes the flowsystem of the carrier. An alternative representation is shown in Fig. 10. The creation of a carrier involves fertilizing it with content. Implicitly this means that flowsystems themselves can be flowthings in other flowsystems.

The absence of content from the carrier in the Shannon-Weaver Model is the result of implementation considerations such as optimization of carrier size and speed of transmission. For this purpose, every carrier is associated with one and only one content. If the recipient knows this association then practically (not

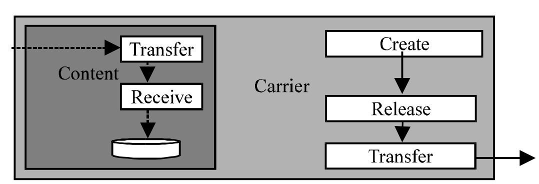

Fig. 9: Conceptually, the carrier contains the content

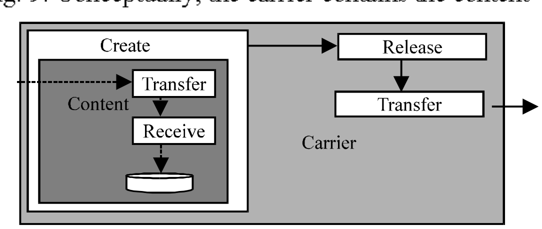

Fig. 10: Alternative representation

conceptually), it is unnecessary for the carrier to transmit that content. The arrival of the carrier triggers knowledge of the content. According to Blackburn (2007):

> Obviously, Shannon's theory requires that the transmitter and receiver both be capable of handling the message. In describing the components in the communication process. The ability of the transmitter and receiver to operate effectively together (i.e. for the transmitter to successfully read a primary message and transmit a corresponding signal and for the receiver to successfully receive that signal and construct a message closely corresponding to that handled by the transmitter) fundamentally depends upon the transmitter and receiver having identical copies of the code

To explain such an idea, let us consider the situation where the carrier actually carries the content as shown in Fig. 11. Suppose the content comprises four sentences mapped to carriers: Happy Halloween, Merry Christmas, Happy New Year, Happy Birthday.

Suppose the sender wants to send Happy Birthday. The sender first constructs (creates) carrier No. 4. Constructing the carrier involves embedding (storing) the language content Happy Birthday inside the carrier. The carrier is released and transferred to the recipient. Upon receiving the carrier, the recipient processes the carrier to extract the content.

Now the recipient knows that carrier No. 4 carries the content Happy Birthday. Assuming there is a common agreement between the sender and the recipient on this after this the sender needs to send only the carrier to communicate the message Happy Birthday as shown in Fig. 12. As described by Reddy (1979):

> The set of alternatives (messages) and a code relating these alternatives to physical signals are established and a copy of each is placed at both the sending and receiving ends of the system. This act creates what is known as an a priori shared context, a prerequisite (within the theory) for achieving any communication whatsoever (Reddy 1979)

Figure 13 shows a general model of communication where the signaling system of Fig. 12 participates in the communication process through the operation of coding and decoding. This general methodology of representing flowthings and their flows can be extended to any level of detail.

Noise created in the channel can fertilize a carrier in the Channel sphere as shown in Fig. 14. Conceptually, the

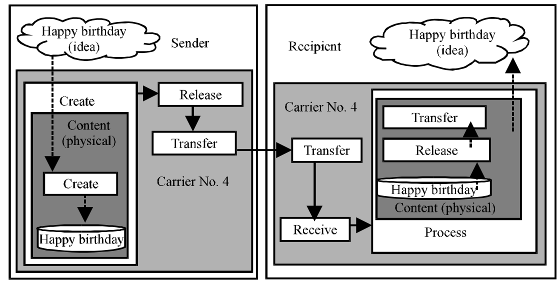

Fig. 11: Conceptualization where the carrier actually carries the content

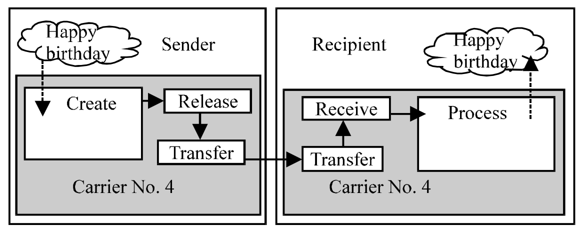

Fig. 12: Conceptualization of situation in which carrier does not carry the content

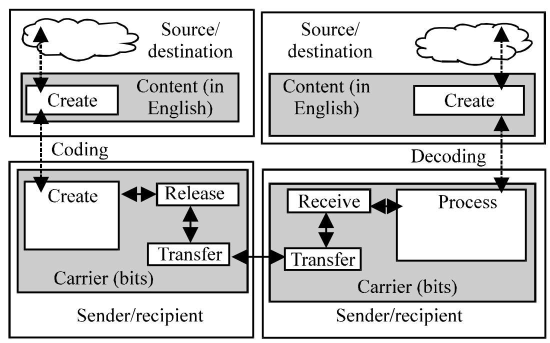

Fig. 13: General model of communication

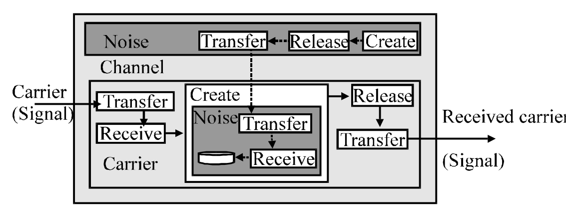

Fig. 14: Noise fertilizes a carrier

carrier that arrives at the channel is different from the carrier that leaves if it is infected with noise (0101 instead of 0100).

RESULTS AND DISCUSSION

Westley and MacLean's Conceptual Model: Westley and MacLean's Model (WMM) of the mass communication process is described as the classical model in the mass

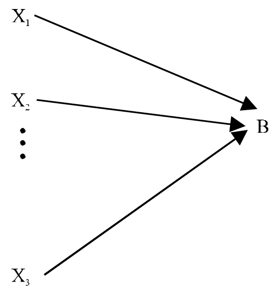

Fig. 15: First version of WMM: objects of orientation (X_1, ... X) in the sensory field of the receiver (B) are transmitted directly to him in abstracted form (X_i ... X) after a process of selection from among all Xs

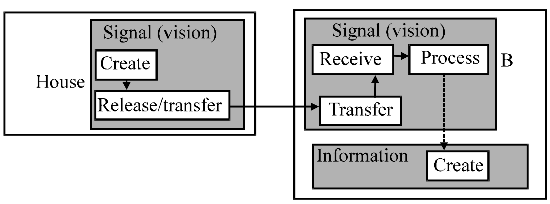

Fig. 16: A flaming house generates information to B

communication field (Stone *et al.*, 1999). It presents an interesting feature of an intermediary level between the source of the message and its recipient (Crilly *et al.*, 2004, 2008). The model applies to all artefacts to which people attach meanings. For example in the design area, The use of a similar representation for design, casts the designer in the role of an intermediary who seeks to fulfill some other party's needs (Crilly *et al.*, 2008).

Several versions of WMM can be presented, each enhancing the details of the previous one. The simplest version is shown in Fig. 15. The Xs represent the information to be directed to receiver B; for example, B looks out his window and sees flames in his neighbor's house. Figure 16 shows the corresponding FM representation which distinguishes clearly between signals and information. It also opens many dimensions. B may not receive the signal even though it is transmitted to B (e.g., B is drunk). Or B does not process it even though B receives it (e.g. not my business) or B does not convert the signal to information (e.g., B is a young child).

In another version of the model (Fig. 17), A represents a person or object with an intermediate role in the communication process. Figure 18 shows the corresponding MF representation. Through this representation we can see the sequence where for example, A and B are cooperating reporters who witness (sensory experience) an accident and send their report in English to each other. The FM representation has several

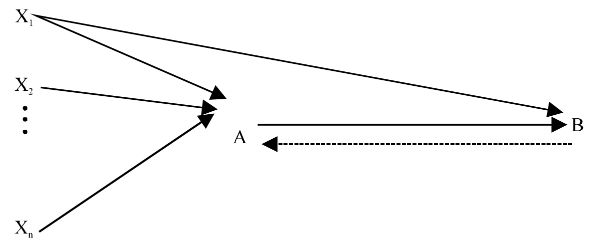

Fig. 17: First version of WMM: the same Xs are selected and abstracted by communicator A and transmitted as a message (x') to B. Whether on purpose or not, B transmits feedback (dashed arrow) to A

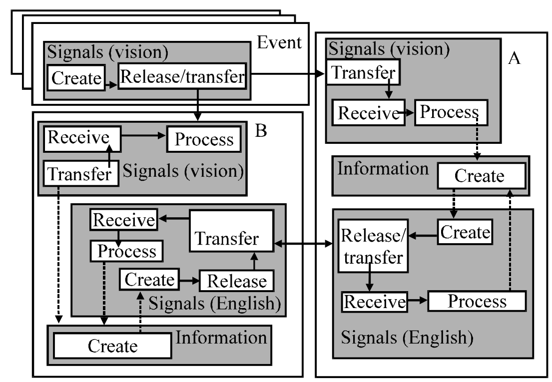

Fig. 18: FM representation of version 2 of WMM

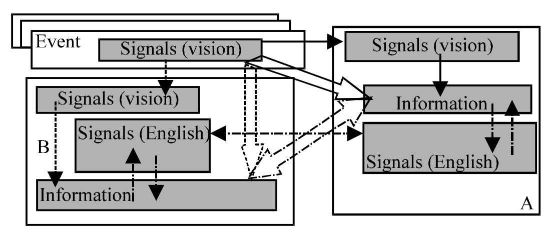

Fig. 19: A brief version of Fig. 18 showing the main directions of information (block arrows)

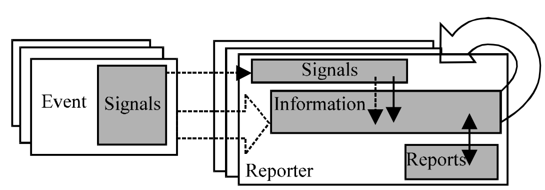

Fig. 20: A generalization of Fig. 18

merits including more precise specification of different types of flows. Figure 19 shows an obvious generalization of the Fig. 18 of this version of the WMM Model that details the main directions of flows of information. Figure 20 shows yet another higher level of abstraction of this type of communication.

CONCLUSION

This study introduces a new Flow-Based Method for representing the communication process that can be applied to many communication models. Specifically, the conceptual representation is applied to Shannon-Weaver Based Models to supplement current understanding of certain fundamental concepts employed in that model. The results seem very promising as a step toward developing a unified approach to the study of communication.

Further research will apply the flow-based representation in two areas. Technically, we can focus on further description of the Shannon-Weaver Model including such notions as noise (Oyediran *et al*., 2010), feedback, element of selection (probability), mutual Information (Samundeeswari and Thiyagarajan, 2010) and the semantics of surprise, often used to characterize this model. At higher levels, we can apply the flow-based representation to other high-level models in linguistics, computer science (Haroonabadi and Teshnehlab, 2009) information policies (Jegede *et al*., 2007), communication science and organizations.

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