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 paper 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. Our 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, p. 20). 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, pp. 5–6), “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 isn't 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. (Foulger, 2004)

In addition, Kaminski (2012) enumerates various weaknesses in the model:

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

This paper 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 paper 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 naïve to regard that model [of communication] as the only model available. Indeed, as K. L. Berge (1994) 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 paper emphasizes the *conceptual representation* of different models, starting with the Shannon-Weaver model. In this section we discuss examples of these representations and their weaknesses in order to show specific motivations for our approach. In the next section, 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…

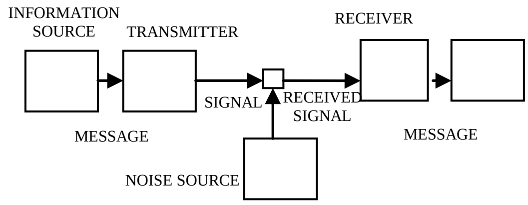

Fig. 1 Schematic diagram of the Shannon-Weaver model

> 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 3) [italics added].

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 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.

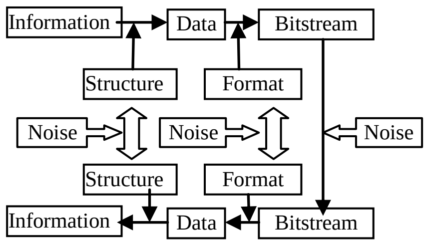

Fig. 2 Information (from Flensburg, 2009))

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 "in-formed". 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's (2009) model.

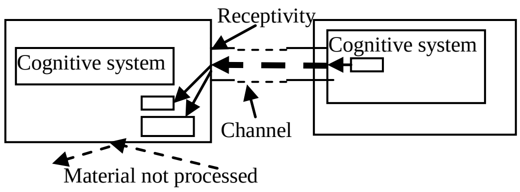

Fig. 3 The context of information (from Lenski, 2010)

This discussion certainly does not give Flensburg's (2009) and Lenski's (2010) 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 our diagrammatic representation is precise and more coherent in characterizing any communication system.

In fact, our 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 authors of attempts to develop semantic theories of information [Bar-Hillel & Carnap, 1952/1964], 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:
1. A *flow* that represents the conceptual movement of flowthings
2. A *triggering* that represents the start of a new thing, e.g., another flow, an operation (Al-Fedaghi, 2005-2012)

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, 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*.

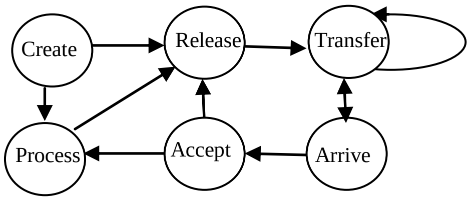

Fig. 4 Flowsystem, assuming that no released flowthing is returned

The logical sequence of different stages is important. Any flowthing (e.g., e-mail) cannot be *transferre*d 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 (2012) presents a model of interactional communication, shown in Fig. 5. From the FM perspective (Fig. 6) , the situation includes two spheres: agent 1 and agent 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.

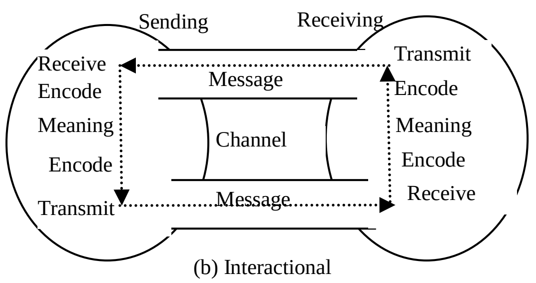

Fig. 5 Communication models (partially from Yates, 2012)

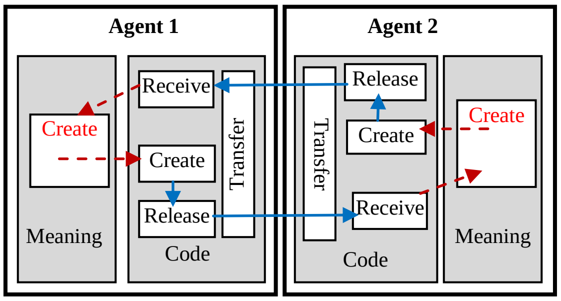

Fig. 6 FM representation of the communication system in Fig. 5

Example: Blackburn (2007) presents Saussure's (verbal) model of communication (see his sources) in terms of the diagram shown in Fig. 7. From the FM point of view, it includes two spheres, each with two subspheres: Mental 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 Trevor, 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" [italics added] (Blackburn, 2007).

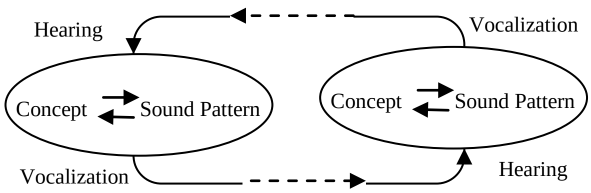

Fig. 7 Saussure's schematic of the speech circuit (from Blackburn, 2007; see his references)

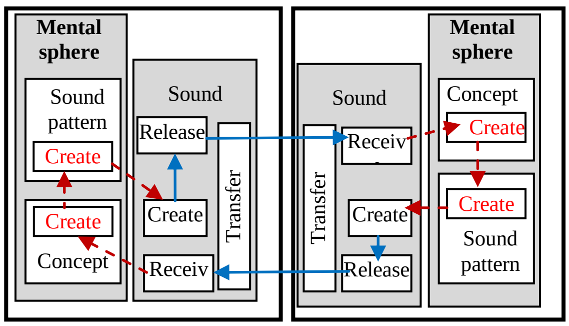

Fig. 8 FM representation of Saussure's schematic of the speech circuit in Fig. 7

According to NPTEL (2012),

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*…
(italics added)

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, p. 303), "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, p. 303),

> 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. Fig. 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 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.

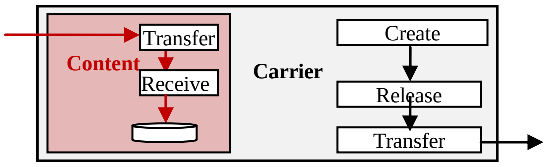

Fig. 9 Conceptually, the carrier contains the content

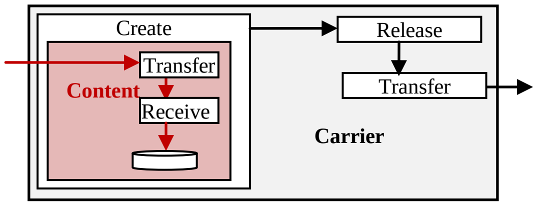

Fig. 10 Alternative representation

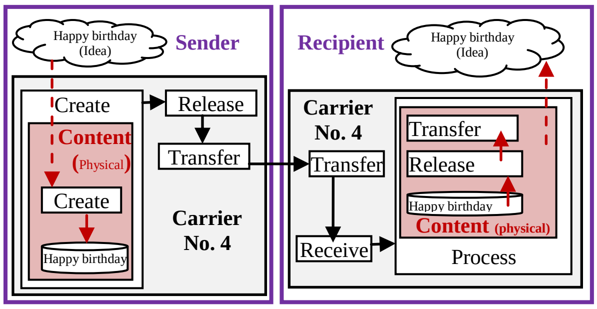

Fig. 11 Conceptualization where the carrier actually carries the content

Suppose the content comprises four sentences mapped to carriers: (1) "Happy Halloween", (2) "Merry Christmas", (3) "Happy New Year", (4) "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.

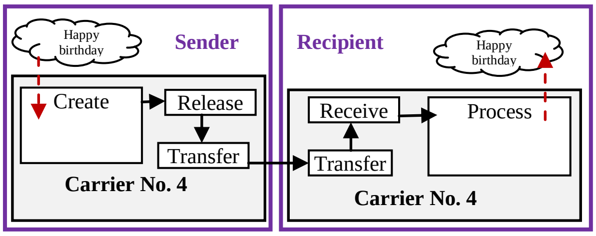

Fig. 12 Conceptualization of situation in which carrier does not carry the content

As described by Reddy (1979¸ p. 303),

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. (Italic added) (Reddy 1979¸ p. 303)

Fig. 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.

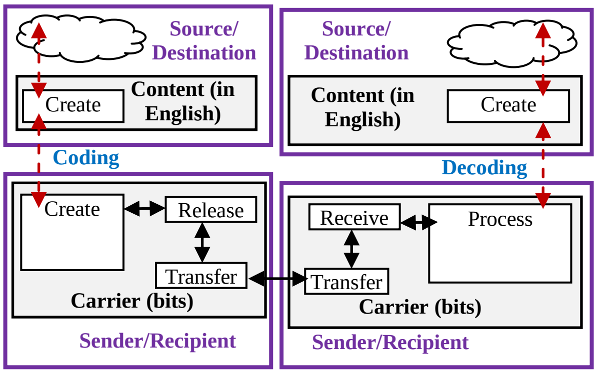

Fig. 13 General model of communication

Noise created in the channel can fertilize a carrier in the Channel sphere, as shown in Fig. 14. Conceptually, the carrier that arrives at the channel is different from the carrier that leaves if it is infected with noise (0101 instead of 0100).

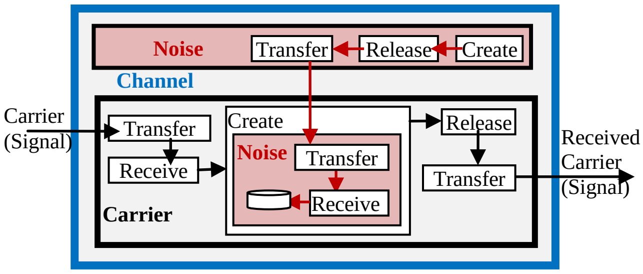

Fig. 14 Noise fertilizes a carrier

DISCUSSION AND APPLICATION

Westley and MacLean's Conceptual Model

Westley and MacLean's (1957) model (WMM) of the mass communication process is described as "the classical model in the mass 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., 2008; Crilly et al., 2004). The model applies to all artefacts to which people attach meanings (Westley and MacLean, 1957). 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 depicted 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. Fig. 16 presents 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).

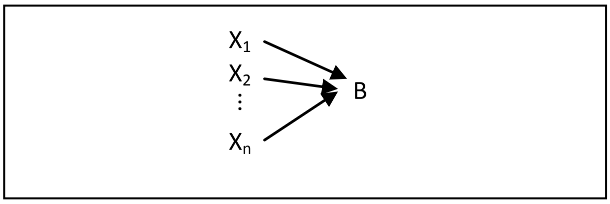

Fig. 15 First version of WMM: Objects of orientation **(X,** . . . X,) in the sensory field of the receiver (B) are transmitted directly to him in abstracted form **(Xi** . . . **X,)** after a process of selection from among all Xs.

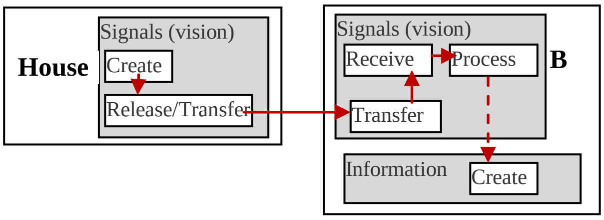

Fig. 16 A flaming house generates information to B

In another version of the model (Fig. 17), A represents a person or object with an intermediate role in the communication process. Fig. 18 depicts 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 merits, including more precise specification of different types of flows. Fig. 19 presents an obvious generalization of the Fig. 18 of this version of the WMM model that details the main directions of flows of information. Fig. 20 shows yet another higher level of abstraction of this type of communication.

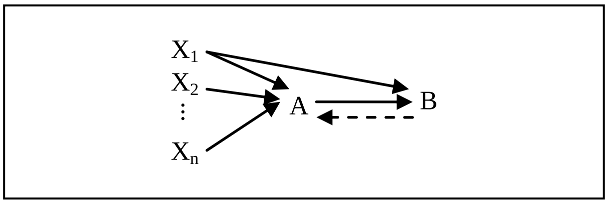

Fig. 17 First version of WMM: The same Xs are selected and abstracted by communicator A and transmitted as a message (x') to B. Whether on purpose or not, B transmits feedback (dashed arrow) to A.

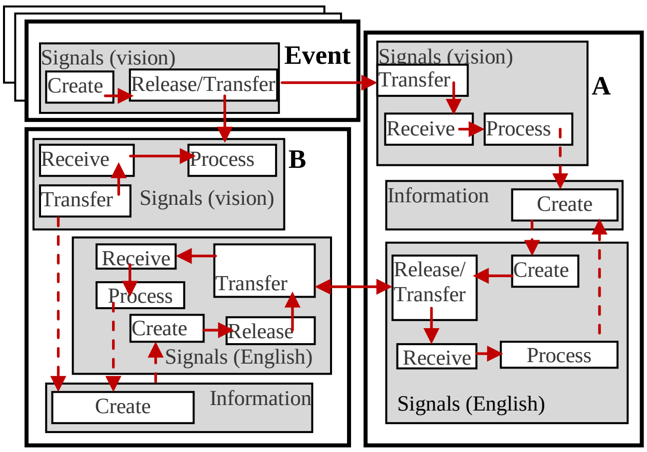

Fig. 18 FM representation of version 2 of WMM

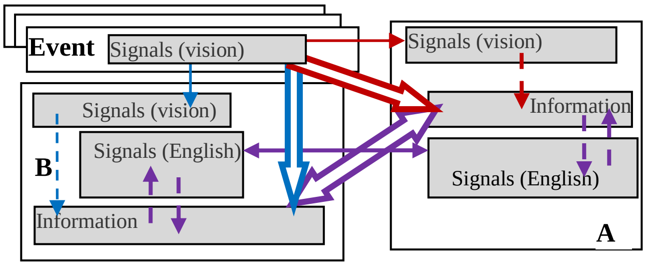

Fig. 19 A brief version of Figure 18 showing the main directions of information (block arrows)

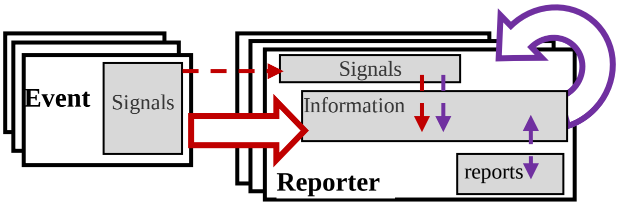

Fig. 20 A generalization of Figure 18

CONCLUSION

This paper introduces a new flow-based method for representing the communication process that can be applied to many communication models. Specifically, our 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 (Samundeeswariet 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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