Report: An Analysis of Communication Models and their Applications since 1948

Monica R. Kimmel and Miroslaw Mutto

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THE STRUCTURE OF COMMUNICATION MODELS AND THEIR APPLICATIONS SINCE 1948

Monica R. Kimmel[1] and Miroslaw Mutto[2]

[1]Development of communicational strategies, Collibri NGO, Gothenburg, Sweden
monica@collibri.se
[2]Communicational strategy advisor, Collibri NGO, Gothenburg, Sweden
miroslawmutto58@gmail.com

ABSTRACT

This paper summarises the models of communication that have been applied since 1948 and their application to various fields where communication is a central activity. In July 1948, Claude Shannon published his mathematical theory of communication, in which the model that has been termed "the mother of models" is illustrated for the first time. We compare the structure of the model with the structure of its offspring and look at some consequences for the various areas of application. Finally, we propose a different structure, a wireless model of communication, that can compensate for the limitations that the structure of the 1948 model has imposed on the areas where it has been applied.

KEYWORDS

Communication Models, Information Engineering, Perception, Ethics of Communication, Quantification of Meaning

1. WHY MODELS OF COMMUNICATION?

For the past seven years we have been involved in a programme running between 2012 and 2032, with the main objective to counteract discrimination towards marginalized groups in society, by spreading correct information about those groups. The targeted recipients of information were both the general public, public sector officials and the marginalized groups themselves. In the status report from 2018, the monitoring authorities report that the transmission of information to the targeted groups had failed. Public sector officials, who were bound by law to both receive the information and to pass it on, had very little or no knowledge at all about the marginalized group's legal rights or status in society. According to a survey in 2019, as few as 5% of the general population had any knowledge of what language-groups the mentioned minorities belong to. This implies that the discrimination and marginalization of the mentioned groups in all public sectors of society persists, and also that the groups' access to their legal rights continues to be poor. Considering the resources that had been invested in reproducing a set of informational units from one point (government) to another (target population), we saw the lack of success in doing so as a minor miracle. We could simply not understand how the information had failed to be reproduced at the target end - in spite of the invested effort and the amount of time spent on that effort. By the disconcerted look on the faces of those who were responsible for the informational transfer we concluded that they could not understand it either. So, we started troubleshooting by looking at what strategies for informational transfer that had been employed within the project.

In doing so, we identified a number of obstacles to informational transfer that could all be traced back to a structural problem - the structure of the communicational model. We use the term "model" and not "models" because although we found a large number of seemingly different representations from a broad variety of application areas, the basic structure was essentially the same in all. We illustrate the details of this structure in section 2.

Some obstacles for informational transfer - like for instance; resistance to new information if it contradicts already implemented information, not being able to interpret information correctly due to lacking interpretative patterns or due to application of interpretative patterns containing false information, application of interpretative patterns that are unsuitable for that particular subject, lack in trust for the source of information, belief that the information is irrelevant or untrue - have a subjective character at the target end which makes them impossible to manage or turn into positives when we follow the map set by the original communication model from 1948. Shannon was explicit about not considering the semantic aspect of communication as relevant to the engineering problem (the problem of transmitting a "message" from A to B), though in spite of this he baptized the model a "general model of communication" [1]. Because of this, the expectations that the model would cover areas like mass-communication, education, cognitive science, development of artificial cognitive systems and informational technology, justice system, communication of scientific discovery, diplomacy, intercultural communication, and other major pillars of societal progress, have been high. An obstacle that we identified as especially challenging was the common expectation that if A targeted B as a recipient of certain information, then it would be impossible that B has not been reached by that information. To this naïve view there was also a presupposition attached; the meaning of the information is a part of the symbols and signals that carry the information. An analysis of various attempts to adjust the model to include the semantic aspect of communication reveals that very little adjustment has been made to the basic structure, the consequences of which are accounted for in section 2.2.

The ethical aspects of a communicational strategy are penetrating all areas since the neutrality of information is in question wherever there is informational transfer. The idea that informational transfer should be unbiased runs through all applications of informational transfer, and many of those areas are regulated by law. In order for at target to trust the informational content of a selected message a large number of conditions have to be met - because of the consequences that *dis*information may have on all areas of society. The incentive to abandon the aspect of meaning from the notion of information has been the connection between meaning and bias. By abandoning the aspect of meaning (or psychological interference, or metaphysical assumptions, or interpretations of reality), the effect is assumed to be unbiased, or "pure", information. If there is such a thing as "pure information", the question we have to ask in connection to the engineering problem is how we can enhance access to this "pure information". If there is not, or if we cannot find a way to access it, we can look forward to dealing with the questions surrounding informational bias management.

In search of a General Theory of Models (GMT), Ritchey (2012) discusses the possibility of creating a Model of Models, i.e. how a model has to be composed in order to function according to demands of scientific objectivity. [2] The issue of bias in modelling theory is by Ritchey described as an obstacle to creating a GMT that is scientifically viable. Referring to Poincaré's (1913) words of warning concerning the refutation of metaphysical assumptions and how this refutation does not mean that we are rid of them, only that we are left with tacit and unconscious assumptions before which we stand powerless to abandon them, Ritchey suggests that we treat this problem as a methodological problem.

To the obstacles in the transmission of information that we mentioned earlier, we could also add the assumption that in managing information, like for instance documentation and transmission of information, one does not make any value judgements. In this respect, Poincaré was absolutely right, it is impossible to get rid of the assumptions if one is not aware that one has them. Therefore, we agree with Ritchey that this is a methodological problem, a problem that necessarily needs to be tackled if we are to find a way to progress the development of communication modelling. A model that is constructed for scientific purpose needs to meet certain conditions. Models are representations of systems or processes that need to be understood, controlled and predicted. The model of a system or process is also supposed to enable an evaluation and/or verification of that system or process. If, for instance, the purpose of a process is to transfer informative content from

A to B, a model of that process should provide us with tools with which we can measure the success of that transfer - without being methodologically biased. Our analysis of the structure of Shannon's model and other models of communication that have been constructed with the intent to solve some of the issues involved in applying the models to human communication, is based on the criteria of verification. The ideal model of communication and informational transfer should thus contain the tools by which we can control and verify the success of the informational transfer. Additionally, a *general* model of communication should be applicable to most communicational situations (if not all), or, be flexible enough to adapt to different communicational situations - even those that were not thought of at the time of construction. Having set the stage for our analysis, we can start with the origins; Shannon's general model of communication.

2. The Structure of the Original Model and the Engineering Problem

In a model of communication, all the components and the stages of the process need to be clearly defined, but the element that stands out as a primary object of clarification is the concept of "information". Since information theory is such a vast area of research, it is impossible to include all perspectives available in this limited context. Instead, we start off with Shannon's conception of information and progress by extending the concept to encompass the element that Shannon and others exclude from the concept; the semantic aspect. The reason that Shannon and other theorists of informational transfer exclude this aspect is, that by including the aspect of meaning there is a risk of losing predictability and control. As Lombardi, Holik and Vanni (2016) express it; "Shannon information is not a semantic item: semantic items, such as meaning, reference or representation, are not amenable of quantification." (2016, p. 7) [3]. Meanings are considered to be dependent on subjective interpretations and can as such transform the informational content of the original message into practically any other content that may suit the receiver. Since Shannon considered the semantic aspect of information to be irrelevant to the engineering problem, we challenge this assumption in section 2.1. by examining the conditions of verification for the success of a transmitted message that lacks the aspect of meaning.

Various attempts to include the semantic aspect into a general model of communication have resulted in loss of predictability. This is mainly due to the difficulties involved in quantifying meaning. We will look at some of these attempts in section 2.2. in order to illustrate why it is so important to account for the roles of all the components in any communicational situation if we wish to construct a model of communication that can predict the result of an informational transfer in realistic ways. In section 2.3. we summarize the structural problems and suggest a list of some necessary modifications to improve the possibility of verification.

2.1. The engineering problem and excluded semantics

The engineering problem is by Shannon formulated as the fundamental problem of communication: "... that of reproducing at one point either exactly or approximately a message selected at another point." [1] While it is fairly easy to understand what is meant by reproduction of a selected content from a point A to another point B - and as the model (Figure 1) suggests point A should be understood as the sender of a message while point B as a recipient - the term "message" needs further elucidation. What exactly needs to be *reproduced* from point A to point B?

The first operation on information that Shannon performs is to exclude the semantic aspect from the notion of information with the motivation that this aspect is irrelevant to the engineering problem. (Shannon 1948, p. 379.) Shannon connects his work to the work done by Nykvist (1924) and Hartley (1928) on the subject of informational transfer. In his paper "Transmission of information" Hartley states from the outset that "A quantitative measure of 'information' is developed which is based on physical as contrasted to psychological considerations." [4]. When Weaver (1949) describes Shannon's theory of informational transfer, he also includes the aspect of "effect" or "influence" to the factors that are irrelevant to the engineering problem [5].

Generally, the term "message" is associated with meaningful informational content that is being transported from a sender to a receiver. In Shannon's theory of informational transfer "message" is translated to "information" in the first explication of the components of the model. The source of the *information* produces (or selects) a message or a sequence of messages intended for some recipient at point B. The next point of transformation for the information is at the transmitter's sending end; the transmitter operates the message into a *signal* that is appropriate for the channel of transmission in question. The channel then carries the signal to some receiver that *reconstructs* the original message from the signal. Finally, the message reaches its destination by being received by the person "or thing" (sic!) for which the message was intended. (Shannon 1948, p. 381.) This is illustrated by Shannon as the model in Figure 1 below. For now, we focus on the "message" and how it gets transported from A to B.

The informative content undergoes a series of transformations (explicit and implicit) during the process of being transferred from A to B, though it must be assumed that it is the *information* that needs to be relocated:

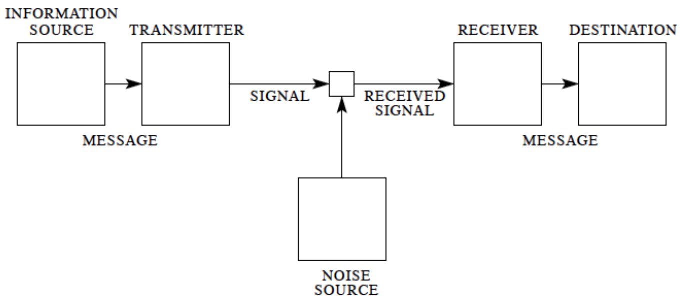

Fig. 1 — Schematic diagram of a general communication system.

Figure 1. Shannon's general model of informational transfer. [1]

Shannon's choice of a logarithmic base for measuring information has remained the classical information unit: "The choice of a logarithmic base corresponds to the choice of a unit for measuring information. If the base 2 is used in the resulting units may be called binary digits, or more briefly *bits*, a word suggested by J. W. Tukey." (1948, p. 380.) A "bit", as short for *binary unit*, is sometimes called a "shannon". For now, we need to clarify what exactly a "bit of information" is, for Shannon and for all the communication theorists that have inherited Shannon's notion of information.

According to the model in Figure 1, it is primarily the *signal*, that which the message first gets transformed into, that can be verified by comparing the ingoing signal from the transmitter with the outgoing signal of the receiver. Any noise that may distort the signal will be traceable by comparing the input with the output. One troubleshooting problem may be the identification of the element of distortion. With the information we get from the model it is impossible to tell if the distortion occurred while the signal was transmitted through the channel, or if the distortion has occurred in the process of the transmitters translation (or encoding) of the message into appropriate signal, or if the distortion has occurred while the receiver has translated (or decoded) the signal into the message that is supposed to reach its destination. The logarithmic base on which Shannon relies to secure channel transmission with high statistical probability, is not explicitly a solution for the processes of transformation of message into signal and signal into message. As

Shannon also notes, some channels do not imply encoding of any sorts, rather, like for instance transmission of messages through telephonic systems "the operation consists merely of changing sound pressure into a proportional electrical current" (Shannon 1948, p. 381). As to the difficulty of talking about information when there is no coding involved, Lombardi et. al. [3] suggest the elegant solution that information should be defined by the "potential but not effective situation of coding" (2016, p. 16). In this way, that which travels through channels may still be called units of information.

Shannon distinguishes between two types of distortions - the ones that result in the *same* distorted output of the message and the ones that result in *differently* distorted outputs. To the first type Shannon gives a simple solution to correcting the distortion; inverse the functional operation on the received signal (1948, p. 406). This means that the source of the distortion can be traced to the functions of the transmitter or the receiver, and that adjustments in either can recuperate what has been lost. The second type of distortion is when the signal does *not* undergo the same change in transmission. This type of distortion is, according to Shannon, *noise*. If the channel is noisy it is generally not possible to reconstruct the message or signal with certainty. Shannon suggest ways to combat noise when transmitting signals. (1948, p. 406) As a part of the suggestion, some more information about the properties of informational units is revealed. Through a noisy channel, distortions of information may be calculated (with the aid of the logarithmic base) by comparing bits of information at input and output. Supposing that 1000 symbols (letters or digits) are produced per second, then the "source is producing information at the rate of 1000 bits per second" (1948, p. 407). This means that the quantity of symbol transmission equals the quantity of informational transmission, so that 1symbol=1bit (of information). Let's look at an example of this informational transaction and try to measure the success of the transmission without considering the semantic or the influential aspects of information.

2.1.1. A meaningless example

If we should take Shannon's appeal for the exclusion of meaning seriously, the information source cannot take any meanings into consideration when transmitting a message from A to B. For the sake of generality, Shannon argues that while meaning is not relevant to the engineering problem, "[t]he significant aspect is that the actual message is one selected from a set of possible messages. The system must be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design." (1948, p. 379). That would imply that the source's selection of message, information or any other content that is to be transmitted, also must be a random selection - at least if we intend to evaluate the efficiency of the model as a model without consideration to meanings.

A set of symbols, randomly selected by source A, may or may not be meaningful. By this random selection we may well end up with a nonsensical "BLA BLA BLA". In what sense this can be called a "message", or what point there would be in transmitting it to some destination, is a question of meaning with which we cannot occupy ourselves in this example.

If the message "BLA BLA BLA" were to be translated to a signal and transmitted through a noisy channel to a receiver that outputs the message "BLU BLU BLU" to its destination, we can permit ourselves to say that some sort of distortion of the message has occurred and that the transmission must be considered a failure. But not a complete failure if we take a look again at Shannon's formulation of the engineering problem; "... that of reproducing at one point either *exactly or approximately* a message selected at another point.". A case could be made out of the fact that "BLU BLU BLU" is *approximately* the same as "BLA BLA BLA" since 2/3 of the symbols came out identical. If we also add the dimension of positionality to this calculus, we get an even higher proximity which satisfies the criteria set in the engineering problem.

This is all very fine until we consider the destination of the message. If the destination B is a "thing" or a machine (a machine is easier to imagine as a target of messages than a "thing"), the machine will with very high probability malfunction or not function at all or function in an undesired way - depending on how it is programmed. Since the *effect* aspect also is considered irrelevant to the engineering problem [5], we encounter a verificational problem at the target end of the informational transfer. The model does not display a feedback function, and without some type of feedback output we have no possibility of checking if the result of the transmission has been "BLA BLA BLA" or "BLU BLU BLU" or something else altogether. Because of the restriction on effect, we cannot verify the success of the transfer at the destination end if the destination is a machine.

If the destination B is a person on the other hand, B has a couple of options - also depending on preset conditions; either the B thinks "oh, there is no such thing as BLU BLU BLU so the source must mean BLA BLA BLA", or, if BLU BLU BLU is preset as something other than BLA BLA BLA, the result could be that the person takes some course of action that is not intended. Another alternative is that the person might think "BLU BLU BLU does not make any sense, so either some delirious source has transmitted it to me, or it was not intended for me at all". All these options also involve meaning and effect. The simplest way to verify this transmission without involving the aspect of meaning or effect would be to ask B if they got the message "BLA BLA BLA". Being a person, B could answer in a number of ways. "What message?", or simply "No!", or if we are lucky "No, but I received the message BLU BLU BLU". The latter alternative would imply that B has made some sense out of "BLU BLU BLU" in order to recognize it as a message though - even if it is identified as a distorted or nonsensical message (whatever a "nonsensical message" may mean). Thus, it seems that the problem of verification is an issue whether B is a person or a machine - if neither meaning nor effect is taken into account.

From this example we can suggest two ways of adjusting the system; either we cut of the destination end from the model (person or machine) or we insert a feedback function that will allow us to verify the success of the transmission. If we insert a feedback function, according to the restrictions on meaning and effect that are set on the model we can still only verify if the pure nonsensical information "BLA BLA BLA" has reached its destination or not. With the proper feedback-function we might also be able to determine what set of symbols (if it is not "BLA BLA BLA") it is that have reached the destination. In the latter case we can also determine at what probability rate the set of symbols have been transported from source to destination. What we cannot determine by merely inserting a feedback function, is if there is a "message" involved in all this. If we refrain from passing metaphysical judgements about messages and what they may be, it must be stressed that the destination of a message is not going to refrain from such judgements. If a machine is programmed to receive a certain code or react in specific ways to a specific code, it will not have the same reaction if it receives a code that it is not programmed to react upon. If a person receives a nonsensical combination of symbols, that person is bound to pass judgement of some sort about that reception - whether they try to make sense of the nonsense or discard it as nonsense. So even if we insert a feedback function to the destination, something might have to be done about the structural part where the destination receives the message.

As Weaver fairly noted, "a theoretical analysis of the technical (engineering) problem reveals that it overlaps the semantic and the effectiveness problems more than one might suspect." (1949, p. 11). Nevertheless, Weaver concludes that "perhaps meaning may be shown to be analogous to one of the quantities on which the entropy of a thermodynamic ensemble depends" and, with reference to Eddington's theory of meaning, Weaver crowns his article with the beautifully constructed: "entropy not only speaks the language of arithmetic; it also speaks the language of language." (1949, p 15). This conception of information reveals that for both Shannon and Weaver, code, symbols and signals are carriers of information and the sources are containers which can liberate and transmit informative content through channels that transport other containers, like codes and symbols and signals. In the even more extreme view that Shannon expresses, the signal, symbol or code is identical to information (1000 symbols=1000 bits of information). This view is inherited by many theorists of information. Although we cannot give a complete account in this context, an example from Dretske's (1981) theory on information illustrates the point [6].

Dretske claims that the hands of a clock carry the information about the time (in analog form). (1981, p. 26.) If understood literally, this view can be a source of much confusion. If the clock is broken or in a transported to another time zone all information that is carried turns out to be false. There is nothing wrong with false information (except the fact that it is false, but the idea of false information is not contradictory in any way), but if we look at how this problem is explained away, we can identify a major structural problem with the model. In spite of defending Dretske's view, Stalnaker [6] claims that; "Information is by definition veridical. According to the simple story I have sketched, x cannot carry the information that P unless it is true that P." (Stalnaker 1998, p. 101). With the example of a broken thermometer, Stalnaker explains that the background conditions, "(or channel conditions)" (1998, p.101), must be accurate for the information to be carried properly. The problem with this becomes obvious as soon as we talk about verification. Stalnaker insists that the thermometer contains the information about temperature and this information is then carried by lightwaves to a perceptual system that receives the information about the temperature. Stalnaker even insists that even if a person is not competent in reading a thermometer (though Stalnaker gives an example about O'Leary getting the information that the zebra is striped although O'Leary does not know what a zebra is), the person still receives the information about the status of the temperature. Just like in Shannon's communication model, the world sends its information-carrying arrows to our perceptual system, the perceptual system (or the machine) is then penetrated by the arrows who plant the information into the cognitive system that is the target of the information. In this sense, it is no wonder that "information by definition is veridical", if the world carries information in itself and makes it available to us through our perceptual system, the world cannot be other than it is, so it can by definition not send any false informational content. This seems to be a conflation between "matter of fact" and "information". There may be no false matters of fact, things are the way they are, but this does not mean that someone can describe things that are not or describe the world in ways that do not correspond to the way the world is.

This lockdown of the notion of information indicates, in our understanding, that Stalnaker is talking about "pure information", that which we briefly mentioned in section 1. This is also how we conclude that Shannon, Weaver, Dretske and many others conceive the notion of information. And as we also briefly mentioned in section 1, if this is the case, the question we need to ask is how that "pure information" can be made accessible to us? This is the BIG question of all science. Since the notion of "false information" still makes sense (we cannot deny that it occurs), the question that remains is how to access "true information". (Or perhaps the question is what we can call information that is false if we cannot call it "information"?) A thermometer is merely a conventional instrument of measurement of the "true information" that is very important to humans in all kinds of activities. These instruments can be broken, just like the perceptual system or some persons linguistic skills. And when they brake, they do not seem to also reveal or send the very important information *that* they are broken. We could spend a considerable amount of energy to figure out why we for the past days have missed the 07.45 train on our way to work, until we figure out that our wristwatch is 5 minutes late. The fact that a watch has stopped is relevant information, information that does not arrow its way into our perceptual system, we have to look for it, troubleshoot. That means that some other type of process needs to be initiated in order to receive information than the passive receptive state that is illustrated in the general model of communication. Developing strategies for evaluation of the instrument with which we measure "pure information" seems essential from this perspective. In the case of communication models, we seem to need another way of describing the event of information being arrowed into its destination.

So far, we have identified three major structural problems with the model; first there is the notion of information that seems both misconceived and conflated with other stuff, second there is the problem of verification at the destination end, and the third is the way that information (whatever it is) reaches the destination. We bring these issues to the next section where we summon all the structural peculiarities.

2.1.2. The structure

We have not yet asked why a message source would create a randomly selected set of symbols or code and transmit this code to an equally randomly selected destination. What point would there be? Signals and codes can be generated in infinite quantities, but if they do not make some sense, like for instance transmitting some important message or creating a certain effect at the target point, why bother overloading targets - whether human or machine - with nonsense? There is actually quite a lot of meaningful information to suffice for any needs, and even this set (the set of meaningful and true messages) is more than any person or machine can grasp or process. And if the source of information is sensible enough to understand this, the source will select (if it is a machine it is governed by patterns of selection instead of incentives) a *meaningful* set to transmit. Most human sources of information would agree that if they wanted to make sure that the mesage they have transmitted has reached its destination, they would investigate whether the meaning of the message has been grasped or if the desired effect has been realized. Bearing this in mind, we can consider the possibility of being selective about information and at the same time selecting "pure information".

As long as we talk about "pure information", the source of information encounters the same problems in being unbiased when selecting the information as the destination is in receiving it. To be absolutely clear that it is "pure information" (non-semantic) we are talking about, we are going to make a temporary (until we find a better way) distinction between *data* and *information*. We can call the non-semantic version of information "data" and the semantic version "information". An illustration of the difference is presented in Figure 2:

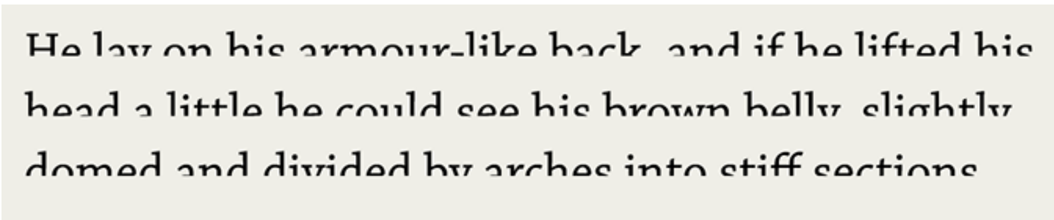

Figure 2. Missing data. [8]

Although half of the data is missing here, there is no problem in accessing all of the information that is represented by the data as if no data was missing. This is important because entropy and noise that affects data transfer may, or may not, affect informational transfer. That implies that information is not identical to data, but not only that, it also implies that information is not contained within data or signals or code. From this example, we can see that the unit of information that Shannon has set to "1 symbol=1 bit" does not seem accurate in at least two ways. First of all, only half the message should have been carried through considering this mode of measuring information. Second, if we do not take meaning into account as the model suggests, no information would be carried through because the symbols have holes in them that do not permit that they contain anything, not even themselves. Without an interpreter of the meaning of the set of half-symbols, any of the symbols taken out of context would probably not be identified as the symbols that they are.

We can be even clearer about the data-as-information part and set a machine as information source (a machine does not run the risk of adding semantic meaning to the sent message). The term "machine" is here referring to any artefact (construction) that is designed for a specific use [9]. We set a machine that is connected to a thermometer which measures temperature at a certain location, and program the machine to send the collected data to a given destination. If that machine were to randomly produce data that it sends to the preset destination, in the case that we have access to accurate data about the temperature in the selected location we would consider the machine, or the thermometer broken. That is because they no longer do what they are supposed to do - transmit "real" data, *veridical* information as Stalnaker calls it. We would perhaps not be inclined to say that the machine is biased when it sends *dis*information (false information), like a scientist would be if he got payed to achieve certain results and then forces those results into his report. But we do find it safe to say that the machine is biased by the selection of correct data that it is programmed to transmit. That is because there is a right way and a wrong way to perform the task of transmitting data. There is no false data (because there is no true data either, there is only data), but data can be falsified (faked) when inserted in the wrong informational context. Like Hollnagel and Woods (2005) express it; "Every system has been designed, constructed, tested, and put into use by people. Every system requires maintenance and repair [...]. Every system produces something, or represents something, with an intended use, hence with an intended user. In system design, people apply all their powers of creativity and imagination to prepare for the eventual application and to guard against possible failures." [9]. *Selection* of data is the result of an act of interpretation - a way to meet specific needs. If nobody needed the information about the temperature at that specific location it would make no sense to set a machine to transmit data about that. If there were no point (meaning) in selecting precisely *that* data, it would not matter whether the machine started producing digits randomly or if it transmitted fake data. The machine is not biased because the machine has no idea that it is transmitting data that gets interpreted into information. But if anybody would like to verify the success of the transmission, they would have to know what type of data that is being transmitted to be able to compare that data with the data that reaches the destination.

In the previous section we identified a set of elements in the structure of the model that may interfere with an evaluation of the engineering problem:

- the notion of information that the model is built on is not fit for transmission of messages, only for signals or code or data
- the representation of how the destination is reached by the message is questionable
- the lack of feedback disables verification of transmissional success
- the representation of the destination as a passive recipient is incorrect

The argument that the information source also is misrepresented in the model with respect to role, gives us a fifth structural element that interferes with the engineering issue:

- the representation of the source's activities is incorrect

To the mathematical model we can say that transmission and generation of data works acceptably if we limit the model to the section that starts with transmission and ends with reception. The processes involved in the transmission of data are *transmission* and *translation*. Transmission is no more exotic than sending a man on a horse to deliver a letter. Translation on the other hand is a process that in the case of natural languages involves meaning - it is the meaning that is being translated not the vehicles, it is the letter not the man on the horse that is the message. Since machines or transmitters of signal do not have the concept of meaning and only translate physical objects, it is people who have to do the translations and build the generators and processors that translate from code to machine-code, from sound to electrical signal, and so forth. Translation in the data-sense means mainly to transform a form into a corresponding other form. The success of the translation depends on the skills of the creator of the machine/transmitter and the encoder.

If we, on the other hand, should get the wild idea to construct a general representation of the processes and elements involved in *informational* transfer (the other alternative mentioned in section one), we will have to tackle the bias-management issue. Before we start erasing or re-directing arrows in the model and re-defining the roles of the information source and the destination, we will look at a selection of attempts to re-insert the semantic aspect of information into the models of informational transaction. The same measure of evaluation that has been used for the Shannon model will be used for the semantic models; how can the similarity or identity of the information sent from point A be compared with the information that has reached point B? In the case of semantic models, it is information that needs to be evaluated. That means that if the model does not have an underlying theory of how to quantify semantic information, the identity or similarity of the output and input cannot be measured. It also means that the model does not offer a solution to the engineering problem.

2.2. Including semantics and excluding structure

There are many reasons to call the Shannon model of communication systems "the mother of models" [9], and a good one is that in spite of all the criticism that has been directed towards the model on account of its inability to represent human communicational processes, its structure still stands as the standard for communication models in all fields of informational processing and transmission. Areas like education, organizational management, psychology and artificial cognitive systems are only a few of the areas that have adopted the model - either straight off as it is or with additions that involve the human factors like interpretation and meaning assignment. In our search for a model with a different structure, or at least one that can compensate for the shortcomings of the Shannon model in social communicational situations, we have not managed to find a single representation that does not follow the structure we have described in the previous section. The structure in simplified form can be illustrated like this:

Figure 3. Simplified representation of the classical basic structure.

Out of hundreds of different representations of communication models that have been applied to various areas of communication, only a fraction (approximately 0,8%) display other structural features. [10] The agency role is invariably ascribed to the source (the sender), the message invariably travels through channels, the receiver is invariably a dormant recipient (if any decoding or interpretation goes on, it is capsuled within the hull), and the arrows invariably penetrate any hull that the source has determined as a destination and impregnates the receiver with information. Instead of occupying ourselves with the hundreds of variations of the same structure, we make an analysis of two attempts to improve the basic model in various ways, starting with the functions that we also have identified as necessary to a model that is suited for solutions to the engineering problem.

2.2.1. The feedback-function

By introducing the function of feedback, Schramm (1954) also activated the destination of the informational transaction. These modifications are necessary for the transmission of information in the semantic sense. The model in Figure 4. is the most used representation of Schramm's communication theory. Both sender and receiver have, empowered by the feedback-function, the power of agency. It allows them to interpret. The argument in section 2.1 was that both encoding and decoding is a form of interpretative act, and Schramm who is practically inclined, acknowledges this. The modifications he has made on the Shannon model is to move the role of the transmitter and the role of the receptor to the source and destination respectively. By doing this he has eliminated the technical noise factor and rendered the channel irrelevant. An operation like this may not affect the possibility of verification very much, though it may affect the receiver’s role as an agent in the act of interpretation and also the encoders responsibility as a transmitter of informational content.

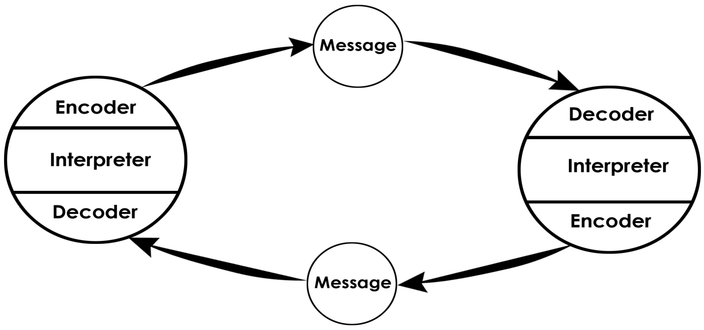

Figure 4. The feedback-function. [11]

The source's choice of channel determines the possibility of feedback. For example, television or radio communications are channels that do not have the possibility of feedback implicitly - one would have to add such a function through a different channel. In modern terms, an answering machine that is supposed to process natural language and provide service by telephone, is more often a source of annoyance then of service, so natural language processing machines are not appropriate feedback channels.

The problem here is that it is the message that travels (in some unspecified way) from sender to receiver and implants itself into the interpreter’s interpretative system. In a way it may seem contradictory to think of a content that needs encoding and decoding, that the code still remains a "message" throughout the process of being transported. Perhaps the direction of the arrows is to blame, or perhaps the notion of information and its relation to data is causing this conflation. However, communication planners who follow this communication model will not be able to figure out how it can be that they have transmitted a message which has reached the perceptive system of the recipients, but the recipients have not implemented the message into their cognitive system. Teachers in public schools frequently find an explanation to this by attributing flaws to the perceptual system of the receivers (the pupils). If the transmission were to be considered as a transportation of data, the perceptual system as channels (which are sometimes bothered by noise, regular or irregular), and the interpretational acts were predictable (quantifiable), perhaps it would be easier to plan a lecture or to transmit a message successfully.

Schramm's model has been criticised for representing communication as a process on equal terms and not taking into account the social fact of authority [11]. This is a fact the we also have identified as a flaw in the model, though not exclusively in Schramm's model, this flaw is inherent in the structural aspect of arrow-shooting information at targets. Some of the discriminatory effect is eliminated by the insertion of the feedback function, though since feedback is not permitted through certain channels, the tellian role of the information source keeps the source dominant even in non-authoritarian communicational situations. Of course, even the feedback, when it is permitted, endows the recipient an equally dominant role by letting the target throw arrows back at the source. In any case, it is difficult to see how this type of exchange can promote education or problem-solving or be of assistance in international diplomatic situations.

Another limitation to this particular representation of feedback is that it necessarily implies that the only type of behavioural output in an act of communication is talking back. This is what we mean by imposing the role of agency (the act of interpretation, encoding and decoding) to a recipient of an informational transfer restrictions in the agency-role. (It is also limiting the amount of communicational situation types to which the model can be applied.) In Linell's (2016) account of agency, an agent is someone who, among other things, can resist an impulse to act [12]. This makes perfect sense to us, since if we posted a sign with the information that smoking is prohibited within the limits of a certain area, we would interpret the non-action of smokers of *not* smoking in that area as a feedback - a behavioural response to the information that we have made accessible to the potential smokers in the area. This instance would be listed as a successful informational transfer. It is important to note though, that the inverse does not apply to behavioural output, i.e., the fact that someone would light a cigarette on the non-smoking area does not automatically mean that the informational transfer was a failure. People smoke in spite of being informed about the risks to their health that smoking may cause. This has nothing to do with information. A strategy for verifying the success of the informational transfer (it could just be that the smoker did not see the sign) would then be to enter dialogue with the person in question.

This example of semantic communication modelling has demonstrated that merely inserting a feedback function is not a sufficient modification of the model - even if it activates the role of the receiver to a certain degree. If the other structural aspects that we have mentioned in section 2.1.2. are neglected, the model may not be useful for prediction (communication planning), verification, explanation or permit connectivity with other necessary elements of communication throughout various communicational situations.

Next we are going to look at a semantic communication model, a model that does not exclude the channel disturbance that Shannon introduced as "noise", but instead transforms it to "semantic noise".

2.2.2. A short story about "semantic communication"

In 2011 a semantic communications team organized by US Army Research Lab report their efforts to develop a theory of semantic communication [13]. In this theory, they intend to follow a vision that the team ascribes to Weaver, to extend Shannon's theory by adding "semantic transmitter", "semantic receiver" and "semantic noise" to Shannon's model. The spark that motivates the team is that times have changed since 1948 and the emergence of new technologies calls for "an extension of the classical communication model to characterize not only *sequences of bits*, but also the *meanings* behind these bits". An indication of where they are going with this is given in the set of questions that guide their progress in developing the semantic communication theory. Their questions mainly evolve around the engineering problem and how to engineer transmission of semantic units, instead of merely physical signals or data, and one of the questions is formulated like this: "How are semantic coding/decoding related to the engineering coding/decoding problems?". The team leans on the formalistic semantic information theories of Carnap and Bar-Hillal (1952) as a method of quantifying semantic information based on logical probability.

Before looking at the model from our perspective and aim, we take a shortcut to the end of the story for the team and let them propose what further work that needs to be done: "these theorems do not tell us how to develop optimal coding algorithms. We note that for both source coding and channel coding, bound-achieving algorithms could be computationally difficult. Efficient semantic coding algorithms deserve further investigation." (2011, p. 11).

The semantic model in Figure 5 displays practically all of the structural properties that we have identified in previous representations. Sender and receiver are boxed in, messages travel on channels and penetrate the boxed in semantic cognitive system with informative content. The model also reveals an implicit assumption about the nature of information, where it is and how we access it, an assumption that is mirroring the description we have made of Dretske's and Stalnaker's conception of information as being a part of the natural world (which in this illustration seems to explode its bits of information into the cognitive systems that observe it), so we simply infer from this that the team also has inherited the "clock carries information about the time"-view. We take a look at the model:

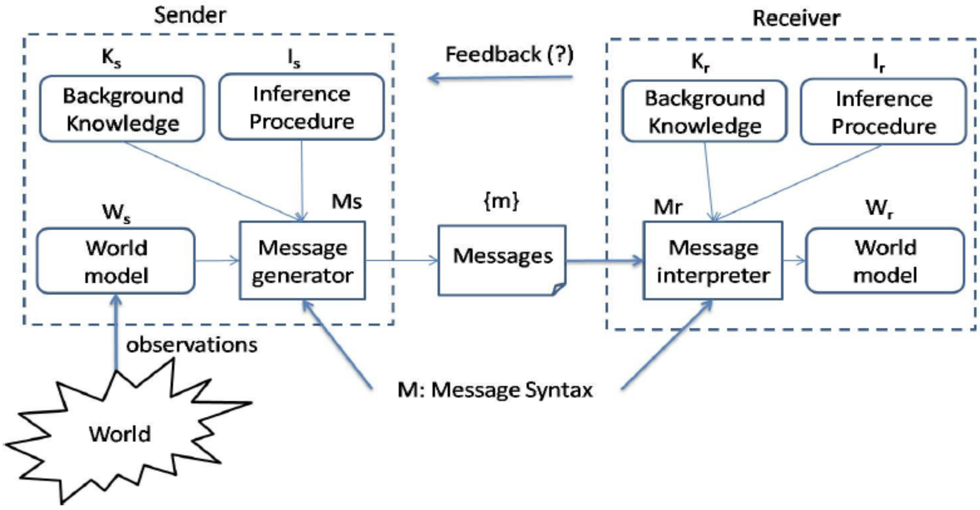

Fig. 2. Semantic Information Source and Destination

Figure 5. Semantic communication model. [13]

The feedback function has a question mark at its tail because the team consider it being an extension that is better left for future work, so we will not comment this but refer to what already has been said about the feedback function. What seems to be new here is that "background knowledge", "inference procedure" are part of the cognitive system's interpretative abilities, and "world model" is something that the system carries to generate messages and which changes when messages are implemented into the system. The elements just mentioned are strikingly similar to what Kimmel (2008) has labelled "interpretative patterns" [14]. This is a good start for a semantic theory of communication (or informational transfer), if (and only if) by "semantic communication" or "semantic informational transfer" one means the transference of meaningful content from one point/person to another. To clarify this, a few words about the semantic meaning need to be said.

There is a strong appeal to the idea that we could develop a system of encoding machines so that they can grasp the "meanings" of the code that they process (semantic coding algorithms, as the team calls them). Because if that were possible, we may very well reach the goal of having thinking machines in the Lovelaceian sense (not the imitation game way, which satisfied Turing), Real Artificial Intelligence. For that to happen, we need to consider the notion of meaning and how it is connected to information. In the sense that the semantic theorists of meaning that we have mentioned so far conceive of meaning, meaning is merely being reduced to structured data. As long as this structure of data is being ascribed to the physical reality, meaning will be something that comes in from the outside, just like the arrows of the models symbolize. Without engaging in a metaphysical debate on the nature of meaning and the nature of physical reality, we can say that the properties of electricity and gold may have been discovered (by gathering data), but refrigerators and jewellery are manufactured (by assigning meaning to that data). In our understanding of Weavers vision, it was not a version of the model that included meaning that he envisioned (se quote in section 2.1.1.), Weaver insinuated that the meaning already is there, inside the structure. In this sense there is no need for a formula for quantifying meaning - we already have it in the quantification of the physical reality that carries meanings; in symbols, codes, signals, and other vehicles that transport meanings. Or as the team expresses it "the meanings *behind* these bits" [13]. If this were true, there would be no need for a semantic version of the model, the classical message transportation system would do just fine.

2.3. Necessary modifications - a suggestion

In the previous sections, we have only reported a fragment of the collected set of models of communication that we have examined. Our analysis of the models that are *not* mentioned in this paper reveals that there is very little variation among the models, and that in spite of the arduous efforts of the communication theorists to provide us with a useful map of the processes and elements involved in various communicational activities, we are still standing in the muddy waters of metaphysical assumptions about the nature of data, information, agency, and meaning. Though it may be hard to resolve the problem of quantifying meaning, the assumption that it is not possible is a metaphysical one, an assumption that may turn out to be a major obstacle in providing a general model of communication. Therefore, it seems that the first step towards a systematic modelling of informational transfer would be to suggest a way of quantifying meaning. Not in the reductive sense that we have seen exemplified - based on the assumption that meaning is *in* or *behind* or *incorporated as* or *carried by* the physical structures that we may identify as data, linguistic expressions, images, and signals. We need to do this in a sense that does not box meanings into a specific ontological field of existence - meanings are not necessarily psychological entities just because they are not physical entities. Meanings may very well be emergent qualities of events that occur when the physical and the psychological (or the conscious) interact with each other. And there is nothing contradictory about quantifying emergent qualities of events that occur when physical and mental realities interact - even if it is a lot of work.

There is a lot to gain from doing this. For instance, the concept of information gets a proper position in informational transfer, a position that makes it possible to verify the success of the transfer. By viewing meaning as a result of an interactional event, we also assign new roles for the sender and receiver of a message. Dependent on the desired result, the sender of the message needs to make a number of choices concerning the selection of data, the proper encoding of that data (the proper mode of presentation), the choice of channel or channels, the destination, and the purpose. During the selection of data and proper encoding mode that the sender has to make, the sender needs to keep in mind the destination of the information that has to be transmitted and the conditions for the information to be decoded, so that the transfer can be as successful as possible. If the sender of the message wants to make sure that the transfer has been successful, it is also necessary to consider a channel for feedback or some other method of controlling the result of the transfer. The "world view" or the "background knowledge" of the sender has very little to do with this if the intent is transmission of some informational content. Rather, for a successful transfer, the sender must gain knowledge of the recipient/s of the informational content, to be able to adapt the encoding and channelling to the conditions of the recipient (this may be the natural language of the recipients, cultural habits of informational reception, physical disabilities that may require assistive technology, and so on). There is a lot of work involved in being a transmitter of information, and those activities need structure and planning and coordination.

For the receiver of the intended content there is also a change in activities. To begin with the decoding process (interpretation of the signal or code) may not be necessary if the point of receiving the message is mainly to pass it on in code format. If the message is to have some meaning for the receiver, the interpretative process may require an amount of energy that the receiver does not find proportionate to invest relative to the assumed relevance of the message. If, on the other hand, the receiver thinks it is important to understand the content of the message yet finds it difficult to understand, the receiver may need the feedback function - the possibility of checking the sources reliability and expectations on the receiver. "Am I supposed to act in a certain way?", or "Should I expect different behaviour from others now?", or "I'm sorry, I did not understand, would you explain this to me?", or "I don't believe this to be true, what is your source of information?". The act of interpreting a signal or code (a structured set of data) is a complex process that needs to be seen as an effect of agency, and that may require inference procedures and the background knowledge of the interpreter, but it is also by interacting with the object of interpretation that meanings can emerge. The receiver may have to read a text several times before the meaning that the encoder (the writer) intended emerges. A scientist may have to repeat an experiment many times before all necessary data can be collected and some conclusion can be drawn, even if the scientist uses her background knowledge and inference strategies.

To summarize the points, we have identified as structural features of the communication model that need to be modified in order to make the model more suitable for prediction and verification of the success of informational transfer in various communicational situations, we find the following:

- we need a way to quantify meaning without reducing meaning to physical structure or psychological events
- we need to open the model for the possibility of connecting a feedback function when such is necessary
- we need to assign new roles to both sender and receiver of messages and have the model clearly represent all the processes that are involved in sending and receiving informational content
- we need to make the model applicable to any type of communicational situation and enhance its connectivity to foreign elements whos appearance in the model cannot be predicted beforehand

Having listed these necessary modifications for a model that is applicable to real communicational situations, next we propose a way of making the modifications without losing any of the necessary properties of the classical models of communication.

3. A New and Different Structure

The modifications to the classical model of communication that we have suggested in previous sections are:

1) changing the position of information (message) to distinguish it from that which is channeled

2) changing the roles of sender and receiver by stressing their agency

3) changing the direction of the arrow pointing towards the receiver to stress receiver agency

4) changing the content of channels from message to code

If we perform these modifications on the simplified structural representation in Figure 3., the result will look something like Figure 6. Just like the representation in Figure 3, the representation in Figure 6 is also a simplified version of the construction that needs to represent all the processes, elements and connection nodes that have surfaced throughout our analysis.

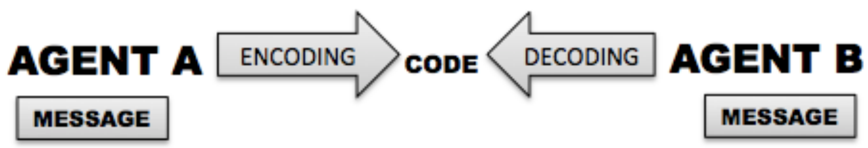

Figure 6. Simplified representation of new basic structure.

Additional features like elements of influence to coding and decoding or nodes of connectivity to various channels of transmission, to feedback, to translators (human or machine), to transmitters and receivers (like the ones affected by noise in Shannon's model), to a set of recipients (like in mass communication), and other elements that cannot be predicted at the moment, need to be represented in a more complete version.

The processes involved in the classical model and that we have identified as transmission and translation (transformation of information to signal or code), have also undergone a minor modification in that they are not necessarily present in all communicational situations. In the new structure, the encoding process represents an agent's *enhancing accessibility* to a certain content for another agent and presenting that content in appropriate form, rather than a transmission of a message. This process includes translation or transformation of content (into appropriate presentational form), though not as a matter of distribution through channels.

As much as we would like to insist upon that information *is* this or that or the third, we still have to leave the question open for the sender of the message to decide what purpose there is in transmitting that particular message. If the intent of Agent A is to provoke a certain type of activity in Agent B, we cannot persuade Agent A that he is not allowed to use information in that way because our model does not care about the effect of a transmitted informational content. Meaning and effect are closely connected in the act of informational transfer, so any agent that is being represented in a model needs a behavioural pattern (BP) representation. It is thus not only the interpretative patterns (IP) that can determine the success of a transmitted informative content. Agent A, just like all agents, also has a BP that might intervene with his skills of encoding or selecting appropriate channels, thus it is not only the sender's interpretational apparatus that determines the encoding of a message (as the semantic versions seem to indicate).

A process that we have not had the opportunity to mention (because of the structural feature that in the classical model is represented by an arrow pointing towards the recipient), but had plenty of complaints about its absence, is the process of implementing the decoded content of a received message into the BP and IP of the receiver. It is thus not only the "grasping" of meaning (understanding) we are after, but also how that meaning gets incorporated into the "world view" (as it is represented in Figure 5) of the receiver. All information we get from the "world" goes through our perceptual system. Even semantic knowledge, i.e. knowledge acquired through the learning of language and interpretations of the meanings transmitted through linguistic expressions. For this we need auditive and visual input. For the auditively and visually impaired there is the substitution of tactile sensory input. Though if the world does not arrow its way into our cognitive system in the way that is represented in the classical structure of the communication models, how does it get in (implemented)? This is a question that we need to answer in order to not leave a wide explanatory gap in the model we aim to present. We provide an account of this by borrowing some concepts from a theory of perception that also will be of assistance in completing the task of quantifying meaning as an emergent property of interaction between physical and mental realities.

To truly be able to identify all the processes and elements that affect the informational transfer (and the prediction and verification of its success), we need a way of determining if it is the case that the content of the message that Agent A is transmitting to Agent B and the message that Agent B has received are "exactly or approximately" the same, we have to start with an account of quantifying the emergent quality of *meaning*.

3.1. Quantification of meaning

If we for a brief moment return to our discussion about "pure information" and our distinction between data and information, we may find associative patterns that can help our understanding of what exactly it is that has to be done when quantifying quality. We have associated "data with "pure information". What it means that information is "pure" is that it is void of content - *informative* content, as we will claim. If information is "pure" it is also devoid of structure. Data may be reduced to physical matter (though not quite, but for the sake of the argument), verifiable but not informative. If a clock is broken, the data that can be extracted from it about the time has false value (except for two times per 24 hours). Thus, it is not informative about the time. If we somehow access data that we can structure into the fact that the clock is broken (x is P), the hands of the clock can be informative of the exact time of day (within 12 hours if the clock is analog) that the clock has stopped. The difference between being informative and not being informative is, in this way of reasoning, very much like the difference between being meaningful and being meaningless. We will use the term "informative" in this sense.

What we have to do is a two-step process; first, we need to show how to separate types of data out of which we can produce meaningful information from types of data that cannot be transformed into informative units, and second, we need to clarify how the meaning-generative type of data can be quantified. Since all data is collected through someone's perceptual system, the structural aspect of identifying, collecting, selecting, counting and differentiating data needs a thorough theory of perception to be completed. Since we earlier suggested that meaning is an emergent property of the interaction between physical and perceptual realities, we start of, with Frege's theory of meaning and complement it with Husserl's theory of perception.

3.1.1. Compositionality, contextuality and Thought

Taken in isolation from Frege's general account of meaning, Frege's principle(s) of compositionality and contextuality result in a circularity that is difficult to break out of, but which nevertheless guides us towards understanding the logical principles behind quantification of meaning. In his *The Foundations of Arithmetics* (1884), Frege claims that "it is enough that a sentence as a whole has meaning; thereby also its parts obtain meaning" [15]. That the parts obtain their meaning from the whole is often described as Frege's principle of contextuality. How does a "sentence as a whole" get its meaning? "The meaning of a compound expression is a function of the meaning of its parts and of the syntactic rule by which they are combined." [15]. "A function of the meaning of its parts..." is often interpreted as Frege's principle of compositionality. The interpretation of these two principles is widely debated in philosophical and computational contexts, a debate we do not intend to intervene with. What we are after here is a way to use *our* interpretation of the principle(s) as a tool to advance the quantification of meaning.

To break the circularity of the principle(s), we need to look a little further ahead into Frege's philosophical development for a better understanding of what a meaningful sentence "as a whole" is. To Frege only complete Thoughts have meaning [16]. A complete Thought is an abstract object that consists of two parts (is binary); a logical subject (a Name in Frege's terminology) and a predicate. Expressed in semantic terms, the complete sentence needs to say *something* about *Something* to make sense, in logical terms (Px) or "x has the property of being P". A Thought may or may not have correlate in a natural language sentence (which is why it is an abstract object) - what makes it meaningful is the structure of being binary. This structure makes the Thought truth-conditional, and therefore the structure (the composition) is a first necessary criteria for meaningfulness. A complete Thought is not an *informative* thought though. A way of understanding this in a semantic dress is like this; if the sentence S (that expresses the Thought [α]) can be valued to 0 or to 1 (is truth-conditioned) then the sentence S is complete, though not *informative* until contextualized. To contextualize a sentence is to ascribe it a truth-value. "One communicates a thought. How does this happen? One brings about changes in the common outside world which, perceived by another person, are supposed to induce him to apprehend a thought and take it to be true." (1956, p. 311). This is how we understand the principle(s) of contextuality and compositionality. As a first condition of meaningfulness the Thought needs a binary structure (compositionality) which makes the Thought truth-conditioned - though not yet informative. The second condition is that the Thought also is ascribed a truth-value (contextuality) and by this it can become informative. It is not appropriate to call these abstract objects "Thoughts" because of their modern psychological connotations. We would rather call them qBits (since they do not have truth-value until an observer ascribes them one). A qBit is a *potentially* meaningful unit on account of its composition. A qBit is not a piece of data though, a piece of data does not have to be binary. In relation to Shannon's theory, a symbol, in contrast to its being a unit of information, is merely a piece of data - it lacks both binary structure and assignment of value. To identify and quantify a qBit is thus not a complex procedure. But how do we identify an iBit (an informative, meaningful, unit)?

Frege puts us on the right path to answering this question when he indicates that in communicating the Thoughts (qBits) we expose others perceptual systems to the Thought (qBit) and if they truth-value the qBit, it becomes an iBit. (Note that this does not mean that they need to have truth-value 1, as Stalnaker and others claim. To be truth-valued to 0 still grants the status of being an iBit, since a 0 value is informative about something's *not* being a matter of fact.) To Frege the question of how a Thought can be grasped was a mystery though, so we have to turn to Husserl's theory of perception to complete the quest of identifying iBits, so that we can finally quantify meaningful information.

3.1.2. Perception as production of quantity

Collecting data from the environment, like for instance checking the clock to see what time a day it is, requires a set of skills that we often take for granted. If we consider these skills and compare them to a computers data gathering and processing system, we might not only appreciate those skills more, we might also find some answers to why information does not travel through channels as data does or is transmitted like signals are. Since we are not in any way wired or connected to the world or other people (like computers are connected to other units that process data) we have to direct ourselves towards that which our interest lays in. For this directedness we borrow a term from Brentano (1874); *intentionality*. Brentano explains the property of intentionality as a property that distinguishes physical from mental phenomena (1995, p.88), and describes this property as the ability of mental phenomena to experience something *as* something (1995, p.97) [17]. As a comment to the simplified model in Figure 6, the function of intentionality is represented by the arrow that is directed towards the code - from Agent B (in the classical model the "destination" or the "receiver").

The notion of intentionality is also adopted by Husserl (1913) - as a precondition to all experience - and outlined in detail with respect to its function in relation to the human perceptual system [18]. In Husserl's theory of perception, the physical world - including the linguistic expressions that are presented by other people - is grasped in the form of raw data, or *hyle* - the Ancient Greek term that often is used to distinguish matter from form (*morphe*) - though in Husserl's theory hyletic material is a term used for raw sensations, perceptual content that may or may not take the form of intentional objects depending on how we treat them (1993, pp. 173-174). An *intentional object* can be practically anything that perceptual acts (intentional acts) are directed towards and constitute as an object. This should not be interpreted as saying that the world we perceive is unstructured, it says nothing about the world, the description of intentional objects merely says something about our perceptual system and how it functions. A hyletic input of "redness" for instance, would not qualify as a qBit since it lacks structure. A perceptual act involving a "red strawberry" would qualify as a qBit though, but to become an i-Bit it would also have to be valued as real or irreal.

An illustration of what this means can be made by comparing this to a general programming problem; object detection programming. Object detection tools are used in self-driving cars, task performing robots, assistive technology and face recognition applications - to just mention a few examples. A simple description of how an object detection program works can also be used as an illustration of what type of effective uses Shannon's model of communication can have. There are many types of object detection models, our choice for comparison is a Deep Learning-based model. In short terms it works something like this; an image is input into an encoder which runs it through a series of layers that extract statistical features (compare to Shannon's logarithmic base for informational transfer) of location and label of the objects, which in turn are sent to a decoder (which is directly connected to the encoder output) that predicts bounding boxes and labels for the objects. Some of the challenges for programmers of object detecting are; 3D localization, speed for real-time detection (important in self-driving cars), limited database for classification and class-imbalance. If we look at the image in Figure 7, to take an example of the result of a process we described, a substantial amount of issues arise. First of all, if the object recognized as a person were a wax doll, the machine would still label the object as a "person".

Figure 7. Unusual scenery [19]

We cannot tell how the tree in the background is classified (probably as background), or the rocks on the ground (probably also background), but if the machine were to label the rocks for instance, would that be "1 pile of rocks" or would it box each rock as 1 individual object? And the tree then, is that one tree or many? And we have not even gotten to the really tricky question yet. If a person were looking for material to make a cane, would not most of the branches of that tree classify as *one* object of interest? The factor of interaction can make anything, even parts of things, into individual objects. A pile of rocks can become a shelter, 100 pieces of electronic junk can become 1 excellent robot, 1 piece of metal has the potential to become 10 pieces of magnificent jewelry. A question that is connected to the wax-doll problem is how we can access information that is not "given" in the image. Collecting information about the age of that tree, for instance, requires interaction. So does information about which class the identified object belongs to. That is how people perceive the world - in contrast to machines.

Husserl's analysis of the perceptual system reveals details about how to collect information that are far more effective than any machine known today. While the logarithmic base of Shannon's model accounts for the statistical probability of noise to cause loss in information, Husserl's analysis of the perceptual system provides us with an account for complementation of data so that information is not lost. The problems involved in providing machines with 3D-vision for instance, is not a problem for perceptual acts. In perceptual acts, in the act of constituting intentional objects, one of the functions of intentionality, is *apperception*. (Husserl, 1993 p. 103.) Apperception is the aspect of intentionality that allows us to perceive that which is not perceptual data, hyletic material. Three-dimensionality and existence are two examples of apperceptions that are not based on hyletic material, it needs to be added. The fact that a tree that someone perceives also is a *real* tree, occupying space and shedding leaves in the fall, is not part of the hyletic material that the person perceives. Objects are, according to Husserl, "set" by us as having an existence independent of our perceptual faculties. Another example of apperception can be illustrated by Figure 2 above, where the missing parts of the text are added to the perception and help us extract the informative content in spite of the missing data.

To finally connect this to Frege's question of how Thoughts (qBits) are grasped, it is, according to Husserl's sharp analysis of perception; by the intentional acts' directedness towards the qBits, the intentional acts that identify the qBit (as a unit) and contextualizes it with the apperceptive act that sets the qBit's value to 1 or 0, thus turning it into an iBit.

Although we may seem to have identified a meaning unit that can be applied to information and be a tool for quantification of meaning which would allow us to verify the success of an informational transfer, this method needs to be complemented in two ways. First, we need to establish the quantitative relationship (is it 1 to 1?) between iBits and qBits, since even if an iBit is dependent on the qBit for its occurrence (meaning is dependent on structure), structure is not the *only* component of meaning. Second, we need to consider meaning as levels; for each contextualization a new level of meaning is added to the qBit, and thus a qBit can be the foundation of a vast amount of iBits. These issues cannot be dealt with in this limited context, and we have to consider our task completed with the separation between qBits and iBits for the purpose of correctly representing the place of informational units in a communicational model.

3.2. The wireless model

In this section we present the result of our analysis while outlining a possible way to represent a large number of communicational situations in one model, a model that also meets the criteria of verification of the success of the informational transfer. The model differs from the majority of models in four interconnected ways:

- the metaphysical wire between the sender and receiver of message, and between the source of message and the world, is cut
- the sender and receiver of messages have acquired a status of agency which can be defined in harmony with the separate roles that they have
- the channel, or the mode of presentation of the message content, has become a variable (as opposed to the constant technical mediation channel), that in any form easily can be connected to the agents involved
- the message - whether technical, semantic or effectual - is possible to quantify, which makes verification of the success of the informational transfer possible

The *components* that necessarily are involved in an instance of informational transfer are:

- at least one agent and at most limitless
- at least one iBit or one qBit (depending on the communicational situation)
- at least one mode of presentation

The *processes* that necessarily are involved are:

- interpretation (includes selection of content and encoding, as well as decoding)
- presentation (enhancement of accessibility, translation)
- implementation (system reception of the message content)

In section 3.2.1. we define the roles of the components and the processes by illustrating some major steps in the process of communicational transfer.

3.2.1. Step by step

The model constructed here is applicable to any type of communicational situation, and any kind of communicational situation starts with some agent that aims to share some kind of informational content with others - even when an agent merely collects data it usually is with the intent to share the findings. If A is a machine, all machines are also set to do some task with a purpose. All gathering of data is set with an intent and within boundaries, to collect all data accessible is not only impossible, it is also pointless. For a machine to collect all data accessible it needs instructions on what a datum is, what it is supposed to do. To give such instructions, one would have to classify all there is, from string level (and probably even below) to magnitudes that are unknown to any man.

We start with Agent A (as shown in the simplified representation in Figure 6) and define this agent as someone who wants to share some information with others. First of all, the agent has some type of source to the information that he wishes to share, whether it is a scientific finding, a logical conclusion that the agent himself has drawn or if the agent merely is a mediator for some message that some other agent has selected. If this content source is to be verified at a later stage of the communication, it is important that Agent A is conscious of the source to the message we can call "α", that in turn necessarily needs to be composed of at least one qBit or iBit. There is a high probability factor that any source will contain or generate a lot more qBits than one, some sources even have infinite amounts of qBits and an even larger set or sets of iBits. So, Agent A needs to be selective. We have not yet defined the quantitative relationship between qBits and iBits, though from what we have said about quantity in section 3.1.2. one can conclude that it is not necessarily (though it can be) a 1-1 relationship. Not all Thoughts are valued, and sometimes many Thoughts are necessary to present in order to communicate one informational unit. If Agent A wants to present a certain amount of iBits to an Agent B, and knows that it is not possible to transmit iBits - only qBits that Agent B needs to transform into iBits - Agent A needs to determine the exact number and value of the iBits and translate them to qBits (in some form or other) that represent "exactly or approximately" the iBits that are to be transmitted. As an illustration of this situation, we can imagine that Agent A wants to promote some behaviour in Agent B. Many times, it is not sufficient to merely present the content "do β". In the case that Agent B needs some type of motivation or incentive, Agent A needs to complement the content β with other types of iBits (and translate them into appropriate qBits) in order to achieve the desired effect. There are many other types of situations in which a certain iBit needs to be translated to other qBits than the corresponding ones (cross-cultural communicational situations for instance) to achieve reception (implementation) of the communicated content, but this is a vast area of research that we cannot develop the details of in this context. Not all communicational situations require that Agent A implements the content α into his or her interpretative pattern system, though for the situations that require translation of a certain content it may be necessary. Some communicational situations also require the possibility of feedback, so Agent A needs to prepare for such a possibility and choose an appropriate channel for feedback. Figure 8 illustrates the first steps of the process of informational transfer.

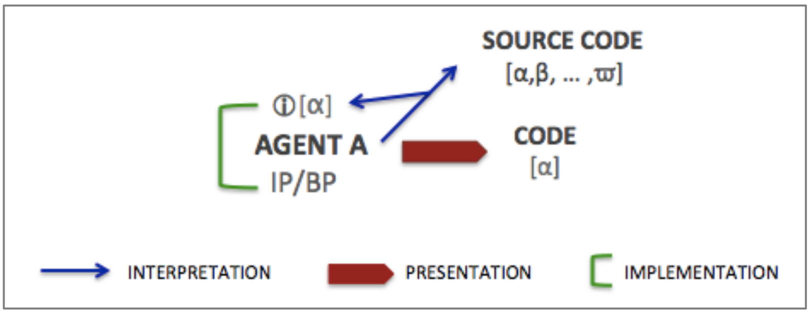

Figure 8. Presentation.

The source code is here represented by content [α,β,...,ϖ] (which are qBits), the act of selecting and interpreting from source is represented by arrows, iBits are represented by ⓘ, the implementation process is represented by the connectivity between iBit and the interpretative and behavioural patterns of the agent (IP/BP), and the presentation (encoding, translation, choice of channel, choice of channel for feedback) of the content by the block arrow pointing towards the presented content.

The next step is at the reception point. There are a lot of conditions to be met here for the presented content to be interpreted and implemented. The processes are the same as for Agent A, though Agent B has not selected the content out of interest so the content may be considered irrelevant to B, who in that case neither interprets nor implements it. If B by chance understands the relevance of the content or is even eager to learn this new information, the information need to pass the barriers of interpretation (requires that the presentation is in a form that is accessible to Agent B, like for instance the appropriate natural language), and the barrier of evaluation (if B has reasons to doubt the truth of the informative content, or to cares to respond to a certain behavioural request), for the content to be implemented into the behavioural patterns of B. Figure 9 illustrates the steps involved in the reception of the message.

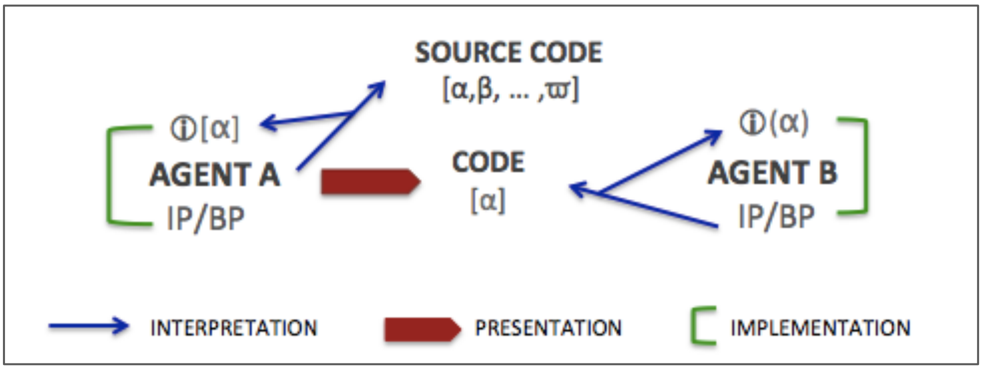

Figure 9. Reception.

If B encounters some challenges in interpretation of the content and A has not prepared for this by opening a channel for feedback, this may also be an obstacle to implementation. Sometimes it is part of the interpretation process to ask questions. Sometimes questions need to be asked only to make sure that one has interpreted the content in the way it was intended. The third illustration represents a way to dialogue.

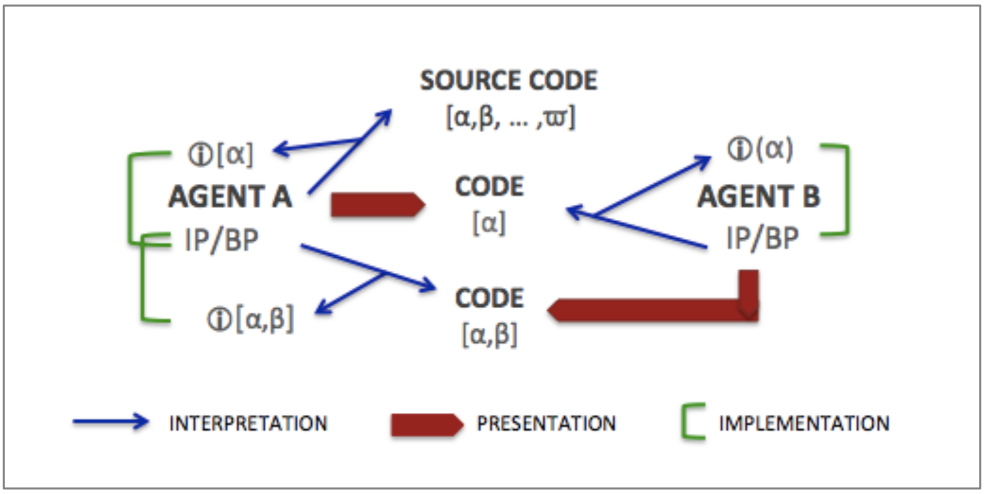

Figure 10. Dialogue.

If feedback is presented by B, the processes need to be repeated by A. The model representing dialogue in figure 10, contains all the steps (components and processes) that need to be present in a dialogue situation. Many times, dialogue is required for informational transfer, and the reasons for this have been accounted for through our many examples. Another reason to enter dialogue would be that there are laws formulated specifically for the eradication of bias in authoritative situations where minorities are discriminated by the public officials who are supposed to protect them from discrimination. This is a subject that also needs to be lifted and examined in a different context, our purpose here was mainly to illustrate how the most complex of communicational situations can be organized by following the wireless structure.

Throughout this paper, we have stressed the importance of flexibility for the model, i.e. to construct the model in such ways that it can be applicable to any communicational situation. In situations like mass-communication or education, it is not necessary to illustrate that any number of agents can be connected to the code in the same way as B is connected to the code. Part of being applicable to various communicational situations is to be connectable to various channels of informational transfer. Technical channels like television or telephony might require the noise calculations in combination with the informational aspects, for the informational transfer to be as predictable as possible. Figure 12 illustrates how a simplified version of the model can be connected to the classical technical model.

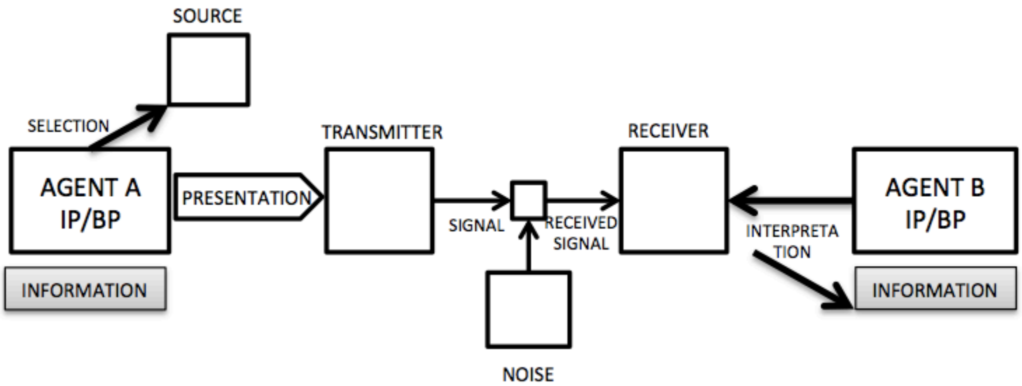

Figure 11. Technical channel connected to the wireless model.

We could of course continue this list of combinations indefinitely and illustrate all kinds of communicational situations. Instead we choose to provide the building blocks for any communicator to construct the appropriate model for the purposes that may be encountered. To enhance the communicator's access to the models building blocks, we end this section with a short list of definitions of the components and processes involved in the wireless communication model.

3.2.2. Definitions of the concepts in the wireless model

The components of the model have been divided into two separate classes: active and passive components. Active components can be understood by their ability to alter the value of the information, while passive components cannot. The units by which we have claimed information can be measured are defined separately under the label "information". Information cannot influence itself, so it has been sorted as a passive component.

The processes involved in the model are classified as three sets that have subclasses of processes whose functions may be affected by the active components. We start with the components of the model.

Passive components:

SOURCE: The source is a passive set of data that can be structured (qBits, here represented by [α,β,...,ϖ]). An example of structured set is a book with content in the form of text. The data (letters and words) are preselected iBits that have been presented as qBits, i.e. presented in the specific form of letters and words in a specific natural language. The book can be viewed as *encoded* information. An example of a source that contains data, i.e. non structured sets of symbols or signals is a thermometer. If it displays the digits 22, 22 is non-structured until someone assigns a scale (Celsius or Fahrenheit), *and* relates this to a specific location, *and* the collector of that data has some interpretative patterns for temperature measurement with all that this implies. 22 is merely a combination of symbols that may mean *anything*. Collecting a set of data with the numerical value 22 can be that one has counted the rings of a tree.

CODE: The form that the qBits (structured data) are presented in. Some examples are; natural languages (in text or speech and in various natural languages), images/illustrations, programming code. When encountering a code, it is possible for a person to decode (which is not the case when encountering data), since a code is based on qBits with the potential to become iBits - units of information.

INFORMATION (ⓘ): Information is the product of an evaluation of structured sets of data in binary form. The unit of measuring information is an iBit, which in turn is based on the non-valued binary (structured) qBit. The value of the iBit is relative to the interpretative patterns of the evaluator.

iBIT: The unit of quantifying information. An emergent property of the interaction between a qBit and an act of assigning truth-value to the specific qBit, by engaging the interpretative pattern system.

qBIT: A set of data structured according to the formula [Px], or "x has the property of being P". The foundation for an iBit.

Active components:

INTERPRETATIVE PATTERN (IP): The set of faculties involved in evaluating, selecting and structuring a targeted content (intentional object). A necessary component in the acquisition and implementation of new iBits, that are either added to an already existing interpretative pattern (like learning the lexical meaning of a word in a language one already knows), or used to compose new interpretative patterns (for example a new natural language).

BEHAVIOURAL PATTERN (BP): The set of mechanisms, autonomous or automated, that result in a specific behaviour in relation to new information. The activities of the transmitter of a message, from selection to presentation, are also to be viewed as a part of an agent's behavioural pattern. The activities of the receiver of the message are also a part of the behavioural pattern of the receiver, including the processes of interpretation and implementation of new content. Feedback is also part of a person's behavioural pattern.

AGENT: An agent is an active sender or receiver of information. Two types of agencies can be identified in an act of communication; autonomous and automated. This is *not* a distinction between human and machine transmitters and receivers of information. All the activities of the agents, from interpretation and presentation to reception and implementation (including feedback) can be performed either by following a pre-set mechanical program, or by actively selecting between alternatives that are more or less suitable for the purpose.

Processes:

INTERPRETATION: There are many types of activities involved in the interpretational process. Some examples are; constitution of the object of interpretation, intentional acts (directedness outwards), selection of perceptual content, apperception, interaction, value assessment (seting the content as real or not, true or false), and contextualisation. All activities involved depend on the interpretative and behavioural patterns of the interpreter.

PRESENTATION: In the process of presentation the transmitter of the message is making the content accessible to the receiver. This involves a number of selections and knowledge about the targets of the message content. To only mention a couple of examples of the selections involved in the process of presentation; selection of appropriate channels and appropriate form of presentation. As a safety measure (to be able to control whether the content has reached the target and whether it has been implemented) it is practical to also make a choice of channel for feedback (like giving the students time to ask questions or making a telephone number public).

IMPLEMENTATION: The process of implementing new content to the interpretative patterns of an agent is conditioned by two primary factors; relevance and assigned value. Because of informational abundance (rational) agents that implement new content need to be selective about the content that is made accessible (and sometimes even forced upon them). If the content is not considered relevant, it may even fail to pass the interpretational filters on account of its contextindependence. If on the other hand, the content is interpreted though valued to 0, there is a very low probability rate that a rational agent would implement that content to their interpretative patterns (unless one also happens to have a category for false content and thus labels it so).

4. A Way Ahead

The technical model of communication (the classical Shannon model) has been fruitful for the construction of informational technology, technology that has developed into applications that are far beyond the limitations that the technology at the time (1948) permitted. Various applications for object recognition, natural language processing and machine learning, are possible due to Shannon's model for channel transmission and its logarithmic base which allows programmers to manage informational entropy. It has not been the purpose of this paper to account for the limitations that are set for informational technology by the model's insufficiencies for an account of the functions of human cognitive systems. The challenges that programmers face when they aim to develop functional natural language processing systems and machines that learn and recognize objects, mirror the challenges that psychologists, educators, and communicators of all kinds are confronted with. If any of these challenges are due to the shortcomings of the classical model, one of the areas that would be interesting to investigate further is what type of informational transfer strategies that can be developed based on the wireless model, in order to improve informational transfer efficiency within any given domain. One research area that has been of interest to the authors and that they would like to develop further, is increased efficiency of the assistive technology developed for the auditively and visually impaired. This domain would benefit greatly from more accurate natural language processing and object recognition applications. Other areas that may benefit are information management in educational and mass-communicational situations, and source reliability evaluation.

A major challenge that remains to be faced in relation to the structure of the wireless model, is the quantificational relation between iBits and qBits. Although extensive work still remains to be done in this area and many factors need to be considered, the authors believe that the model indicates that this can be done if the interpretative and behavioural patterns of agents engaged in communication are viewed as functional indicators. Research on the functions and processes involved in the interpretative and behavioural patterns of rational agents, may also advance the questions of bias management to develop into sets of questions to be taken seriously and worthy of our efforts.

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