Thesis

Optimising the communication chain.
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1. Introduction

1.1 Chinese Whispers

A chain is only as strong as its weakest link.

Lets play a game, it's called 'Chinese Whispers'. For those of you who don't know it by name, you probably played it when you were young. The game starts with a group of people forming a chain. The first person makes up a sentence, which is whispered in the next person's ear. This continues until the sentence reaches the last person. He or she pronounces the sentence out loud. Usually the sentence changes throughout the game. The longer the chain, the higher the chance that the end result will differ from the first sentence. This is due to the increasing amount of steps where something can go wrong.

This brings us to the quote; "A chain is only as strong as its weakest link". The problem is that information is interpreted and processed during each step of a chain. After interpretation and processing, it's passed through to the next step. It's only logical to conclude that with every step an error can occur. By reducing the the amount of steps, and thus the complexity of the chain, the chance of an error occurring, and the chain breaking, can be reduced greatly.

1.2 Slim down or pile up?

Since the birth of the internet in 1989, it's underlying structure hasn't changed a lot. Sure, a lot of new layers, services and techniques have been added. The internet was officially intended to store and share data. While in the current day this is still the main use, the definition of storing and sharing data has been stretched a lot. There's Netflix for video, Spotify for audio, and Bookmate for complete books. You could conclude that the internet has become truly multi-medial. Not only the content has changed though. The way this information is presented to the end user has changed a lot as well. From simple pages filled with text, structured through a script language called HTML. That until the birth of version HTML4 in 1997 officially didn't even have any form of visual markup. To large web

applications with specifically designed interfaces.

All of these advancements have been achieved on the same structure that was basically designed back in 1989 by Tim Berners-Lee. Of course, computers have become more powerful, and techniques like css, ajax and sockets were introduced in the last decade. But still, it's a remarkable fact that this is all still possible on the same structure that was built for text pages.

If you're developing software you're mostly defining behaviour of the application. This behaviour is a set of exceptions based on cultural differences between the user and the programming language or framework. The user needs to be able to communicate with the system after all. Think for example of localisation and time zone differences, but also different user roles, security, user preferences and authentication. They're all real life habits and standards which we're trying our hardest to port to the computers.

This also counts for the protocol and application stack of the world wide web. In order to serve the web to a immensely varied user base a lot of behaviour/cultural differences and needs needed to be defined. But somehow this feels wrong.

1.3 The internet as a tool for humans

> **tool|tu:l|noun** A device or implement, esp. one held in the hand, used to carry out a particular function.

Tools are extensions of humans which enables them to do stuff which they normally can't do. A hammer extends the arm and is able to deliver an precise and more heavy impact to an object, a nail for example. Without this hammer, humans wouldn't be capable of driving a nail into wood.

The internet is functioning as a tool for exchange of information and communication and thus functions as an extension of humans. Where as you wouldn't create a hammer with laser pointer and interchangeable head and all other sorts of extra features to achieve your goal. The same applies to communication. You want to keep it as simple and effective as possible.

1.4 The problem

We think the communication process might have the possibility to be improved as it's getting old and the usage changes. We want to slim down the complexity of the chain between humans and the resource. Currently information travels through a lot of chains or proxies like servers, software and devices (laptops or mobile phones for example). By removing or optimising as much steps in the chain as possible, we think we could make the whole process of using internet services easier, and less prone to errors.

We asked ourselves:

> How can the connection between a human and the internet become more efficient?

To allow us to create a new future vision in which we answer that question, we need a solid understanding of the current communication chain.

2. Communication chain

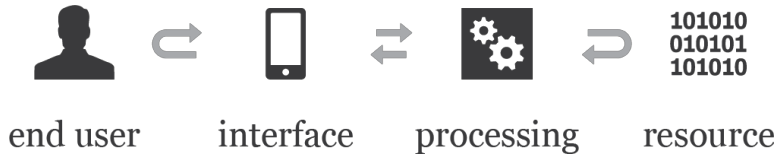end user   interface   processing   resource

Figure 1. Overview of the communication chain according to us.

We view the communication chain as a chain of 4 steps, or layers, allowing a user to interact with information. Each step has it's own functions and responsibilities.

2.1 End user

This is you, the user that's trying to interact with a resource. Using your body to control a mouse or any other input device. Navigating through information on the interface which your senses interpret. For example your voice controlling a phone, which gives audio feedback that your ears interpret. Or another example, your fingers controlling a touchscreen which presents information on the screen that your eyes can read.

2.2 Interface

The interface is the gate or proxy between the end-user and the data. The processing layer prepares the data. The interface receives information from the processing layer which the user requested. Then tries to render the information as intended and presents this to the user, ready for the user to be interpreted.

2.3 Processing

The processing layer serves the resource, making it accessible to the public. It processes the request from the interface, retrieves the data from the

resource, and usually returns a usable form of the resource back to the interface. It often takes care of the shielding of the resource as well. Only granting the right users access to it.

2.4 Resource

The resource is the data the user is requesting. It can be stored through the use of a database or any other form of storage, processed by a special algorithm or not. The data can be stored, retrieved, manipulated or removed.

3. Optimisations

Now that we know about the current communication chain, we would like
to suggest a set of optimisations which we think will optimise the
communication chain. These optimisations are based on our findings
during our research or real-life experiences. Some of which we have
already been able to test and find out to be working.

3.1 Semantics, Optimising data itself

> **semantics |sɪˈmantɪks| plural noun** The branch of
> linguistics and logic concerned with meaning. The two main
> areas are logical semantics, concerned with matters such as
> sense and reference and presupposition and implication, and
> lexical semantics, concerned with the analysis of word
> meanings and relations between them.

The web unfortunately is not readable like a database with structured data.
This is because of the loose structure in HTML. HTML was intended to be
easy to use, flexible. But because it's so flexible, you can omit a lot of
descriptional information about your data. For easy machine readability,
computers need context and a specified set of rules. If a human reads an
article on the internet, he could quickly distinguish the topic, writer and
other data from the text. On top of that, based on the websites the user was
browsing before, and the context of the current one, a lot of extra
information could be extracted. Computers don't work this way. By default
they're not flexible at all. Based on the rules mentioned before, they will try
to interpret the data and it's structure, and grab everything they
understand. When there's no ruleset, the computer does not understand
the information.

3.1.1 The Semantic Web

The Semantic Web, a W3C movement lead by the Tim Berners-Lee aims to
make unstructured data into a 'web of data'.

> Semantic HTML refers to the traditional HTML practice of

markup following intention, rather than specifying layout details directly. For example, the use of "em" denoting "emphasis" rather than "i", which specifies italics.

One of the proposals of the Semantic Web movement is RDF (Resource Description Framework). It's is one of the attempts of W3C to bring queryable and machine readable metadata to the web, a specification for xml. It is designed to be the Lingua franca (a language bridging between two other languages) "to allow data to be processed outside the particular environment in which it was created, in a fashion that can work at Internet scale" and "Interworking among applications: combining data from several applications to arrive at new information." ([Klyne, 2004]) SPARQL is the accompanying query language for RDF, which allows the user to easily search through RDF data.

3.1.2 Metacrap

Unfortunately there are not many real world examples of the usage of RDF. Cory Doctorow has 7 arguments for this in his essay "Metacrap: Putting the torch to seven straw-men of the meta-utopia". He states that it's practically not possible because of the lack of discipline from the users side. In short: describing data is freely interpretable, prone to errors, subjective and requires a lot of work from the user side.

We can't expect people to organise their data semantically. There's a big difference between ordered data for computers to calculations over and unordered data for humans. The easiest way would be by not having to add an extra translation layer. Keep data from humans for humans and data from computers for computers. Unfortunately this is not yet the case. We still need to pipe data from humans through computers.

3.2 Graphical interface layer

Even in a perfect world where all data is structured semantical, the presentation of the interface layer is still freely interpretable. Deciding which data should be presented to the end-user at what time is something that is decided by the interface designer. Interfaces are designed by different people and by definition will have different ways of presenting

data. Methods and patterns can be copied. But in the end, designing an interface is manual labor.

A designer can choose what data is relevant in which situation and present it to the user. The problem with this is that the data decided to be left out is missing. It might have been done because the designer thought the relevant data would be easier to be find. Or because the remaining data just didn't fit the interface. Even though the data might've been available, it's just not there for the end-user to be found.

If you're lucky, a content strategist was present during the creation of a website. Someone who's specialty it is to find out what information should be presented to the user at each specific moment. But even then, even when all of the right information is present when you need it. The interface layer can still make the information hard to navigate.

What can we do about it? Not much, except for hope for better content strategy. Every website needs to be designed as long as we're limited to interfaces with screens. The theory behind Metacrap even applies to the designers of the interface.

3.3 Page based navigation

> The web was originally conceived and developed to meet the demand for automatic information-sharing between scientists in universities and institutes around the world. ([CERN, 2013](#))

The web is designed for sharing scientific articles. Going from article to article by clicking links. Searching the knowledge we're looking for. But instead of taking the page corner the web provides hyperlinks. Because there can be more than one hyperlink on a webpage, the reading experience has become non-linear. Different paths can be taken to end up with the desired data.

According to Steve Krug, interaction designer and author of Don't make me think, we feverishly scan webpages. Looking for anything that slightly resembles what we're looking for. When the page appears not being the one we were looking for we're back where we started with one click of the back button. ([Krug, 2005, p. 21](#))

This behaviour is natural to us humans. While web pages are designed to have a structure and make it easy for us to navigate through websites. We rarely ever read all of the content.

This is a bit like removing the graphical interface as discussed in the previous section. The web would need better semantics if we want to breach this page to page flow. If it would work tough, it would make search engine not returning pages but answers to the questions you put in, a thing Google is working on.

3.4 Removing the processing layer

We believe that removing the processing layer from the communication chain is a possible optimisation. If we want to make this possible we have to come up with a solution that completely renders the processing layer useless. Other layers in the communication chain will have to take over it's current responsibilities.

3.4.1 Interface taking over processing

Over the last years interfaces started getting a lot more powerful. This means that the interface is slowly getting more and more capable of running heavy calculations without the need of a processing layer parsing and formatting data. All of the processing and formatting can nowadays easily be done in a modern-day interface.

The processing step in the communication chain could literally be rendered useless. With a resource which is directly accessible from the interface, and an interface which contains all the processing, there would be no need for the processing step. Periodic tasks and very heavy calculations on large datasets can be delegated to dedicated processing platforms where needed.

This allows us to strip one of the steps in the communication chain, and thus move towards a better optimised communication chain. There is one issue though, we need an internet faced resource to make this happen.

3.4.2 Internet faced resource

Typical resources as we know it (databases for example) are not accessible to the interface. And even when they are, are not designed to be accessed directly by a large public of users through the interface. Resources which are designed to handle a direct connection from the interface can help in rendering the processing step useless.

The problem is that, these resources have to be able to take care of different users and their privileges. When a resource is exposed to the public, you want to make sure that your personal data actually is personal and can not be viewed or even altered by someone else. This increases the responsibilities for the resource layer. Managing authentication, and who has access to what data is currently one of the responsibilities of the processing layer.

During our research we've tested a resource called CouchDB. Essentially it's a resource which exposes it's data to the internet. It allows the interface to read data directly from the resource. Which means that you don't need a processing layer to request the data from the database, process it and serve it to the interface. The database can take care of the serving of information by itself. And the interface can do it's own processing on the incoming data.

A setup which, combined with the previous step of the interface taking over the processing layer, truly renders the current processing layer useless.

3.5 Alternative input

Keyboards and computer mouses have been a standard for a long time, but new more intuitive input methods are arising. The reason for this is that the current input methods aren't as natural as our everyday interactions with objects. The level of control in real life is so much more granular. A lot of improvements can still be made in the field of input methods. (Victor, 2011) Allowing the end user to have a more efficient or natural connection with the interface.

3.5.1 Gesture based input

Gesture based control seems to be a trend. Touch screens and the Apple touchpad allow for touch based gestures. Where devices like Kinect, Leap

and Myo (more on these later) take a different approach. They track your movements and allow you to freely interact with an electronic device in 3D space. Usually freeing you from your desk or at least replacing (partial) functionality of the mouse. Natural gestures could be faster and less error prone than through the use of a mouse click.

"The Kinect is a motion sensing input device by Microsoft for the Xbox 360 video game console and Windows PCs." ([Wikipedia](#)) It has a camera that tracks your whole body and it movements. It's still quite rough, large movements are needed to trigger an action. The LEAP takes a different approach, Wikipedia ([2013](#)) has a good description of the device: "The Leap Motion controller is a small USB peripheral device which is designed to be placed on a physical desktop, facing upward. Using two cameras and three infrared LEDs. It is designed to track fingers (or similar items such as a pen) which cross into the observed area." By limiting the area, the movements can be tracked on a much more granular level. Precise finger gestures make the LEAP very usable for interaction with applications that require precise control rather than large gestures. According to Thalmic Labs, the company behind the MYO, their product can be described with the following description: "The MYO is an armband that measures electrical activity in users' muscles giving them the ability to wirelessly control and interact with computers and other digital consumer products." ([Thalmic Labs, 2013](#)) This would take the LEAP's approach even a step further by removing the camera and tracking muscle tension on the lower arm. Which results in freeing the user from any location or direction based limitation.

Of these technologies, the only one that's in production and has been actively used for different projects is the Kinect. The device was originally intended for Microsoft's XBox360. Even though the device is connected through USB, no drivers had been made available for other platforms than the XBox. Quickly after it's release independent developers created their own drivers, and soon it could be used to control platforms other than the the XBox360. Yet, this lack of open support for the device prevented a wide adoption of the product. Nowadays Microsoft does provide an SDK and drivers for windows. Unfortunately, it did not help the device become a standard. Mainly because it lacks granular control which newer announced devices do have. ([Microsoft, 2013](#))

The LEAP has already gone through a developer beta phase and will start shipping first production models starting May 13. A collaboration with HP

has been announced, the goal will be to integrate the LEAP into HP's hardware. A device like the LEAP won't appear in mobile devices anytime soon, as its hardware is still to large. But a next iteration of the product in the near future could already slim it down significantly. The involvement of a big partner like HP might provide the company with the needed money and resources to quickly push the LEAP to a certain maturity, and allow it to become an industry standard. Wether or not this technique provides an optimisation to the communication chain is still to be proven. But the granularity of it's control might give it advantage over the Kinect. Especially if it gets integrated with mobile devices in the future. ([Leap Motion, 2013](#))

There is an issue with these alternative inputs though. It's a term from the 1980's called "Gorilla arm". When you use a desktop monitor with touchscreen functionality, your arms and shoulders will quickly fatigue. This happens because of holding your arms horizontally and reaching out to the monitor for long durations to constantly touch the screen. This same phenomenon could be applicable for gesture based input devices. The Kinect requires you to do large gestures, allowing you to use a lot of different muscles, and not stressing a couple of them for a longer period of time. The LEAP on the other hand (for now) relies heavily on pointing to your screen, this could replicate the gorilla arm phenomenon. Because the MYO is completely location & direction agnostic, it would be highly unlikely for it's users to suffer from this problem. ([Pogue, 2013](#))

The MYO is set to ship late 2013, early 2014. If it's able to deliver, it could change the way we control our devices. Completely freeing you from the direct proximity of your device, communicating gestural actions through bluetooth to the target device. Using it as a remote for about any electronic device in our home. This could be the phone in your pocket, computer in the next room or music setup in your closet. That is, if it's able to manage target selection well. In other words, the device should know what device you're targeting with every gesture. When you turn the volume of your music setup down, you don't want it to go back up when you try to answer an incoming phone call seconds later. ([Thalmic Labs, 2013](#))

3.5.2 Voice based input

Voice command algorithms have been around since the 1970's. ([Berkman, 2013](#)) But only recently have they become decently usable. Because of the high complexity of human speech, it's hard to write good algorithms that

understand each person's voice. Using simple commands to control a phone, to call a friend for example, can often prove difficult. The recent evolution behind the voice recognition software is driven by the use of a neural network, in short they used an algorithm that works like your brain. (McMillan, 2013)

With the recent breakthrough, voice recognition has the potential to become an input method that could outperform the mouse and keyboard standards we're currently used to for desktop interfaces. The problem is that it's still too error prone to replace either of the two. For mobile interfaces it's already able to enhance the experience significantly. This is because input methods on mobile interfaces are not as effective as on the larger desktop counterparts.

3.5.3 Conclusion

We believe that voice based input just like gesture based input can enhance the interaction with the interface. They can make the process of interacting with the interface more natural, less obtrusive. We don't think they will be able to efficiently replace a keyboard for inputting text though. For example: You wouldn't want to dictate a rather large text to your phone or computer in a crowded environment. Just the same as you probably would feel a bit uncomfortable making some weird body movement to turn up the music on your headphones or remove a file from your computer while in that same environment.

3.6 Wearable interface

With the announcement of Google Glass back in april 2012, a new kind of interface has the potential to become a mainstream interface. The wearable or natural interface. The concept of a wearable interface is already rather old, Steve Mann started working on this topic back in the 80's. But with recent developments in wireless technologies, energy and computational power, wearable devices are finally approaching unobtrusive forms. Google Glass for example is almost the size of a regular pair of glasses. And the near future could see the whole technology integrated into the rim of regular glasses.

Manufacturers are expecting their technology to become ever more powerful and smaller. Based on historical progress and current developments, we can expect wearable interfaces to integrate into small accessories or even our bodies in the foreseeable future. Combined with the removing of the processing layer wearable interfaces could really cause a fundamental change of the communication chain.

3.7 Brain Computer Interfaces

Let's take a closer look at the end user. The human brain is amazing when it comes to input from the senses. It adjusts itself to whatever sensory input it gets and what function is used the most. This is called neuroplasticity. ([Hawkins, 2004, p. 106](#)) This is due to the fact of that every sense comes in the form of spikes, electrical pulses. The brain is capable of learning how to handle these pulses by recognising patterns. This way you could design a completely new type of interface which integrates better with the end user.

These interfaces are called Brain Computer Interface or BCI's which are devices which enable to read (and in the future write to) the mind by translating electrical activity to signals which can be interpreted by computers.

3.7.1 The plasticity of the brain

There's a real world example of a man with retinoschisis, a rare disease which makes you blind after a couple of years, whom was able to see again through a special device. The device, called [Brainport](#) , is basically a webcam which is wired to output little electrical pulses to the users tongue. So, the webcam sends its digital signals directly to the tongue. ([Layton, 2006](#)) After three months the man was able to see again after being accustomed to the signals coming in. This is one amazing example of the plasticity of the brain. ([Levy, 2008](#))
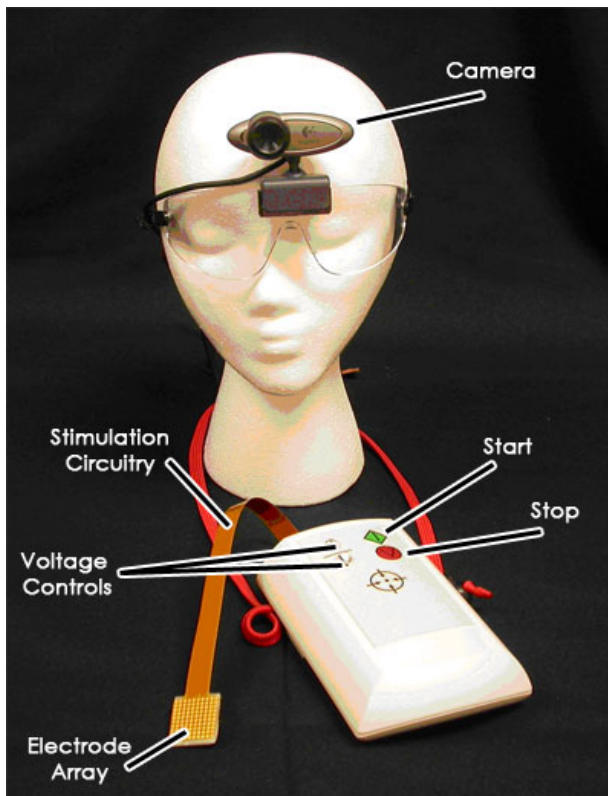
An other example is a colourblind man who is able to perceive colours through sound. Movie World's first cyborg

Imagine a device that somehow feeds the internet as a sixth sense. No need of a screen or keyboard. Applied properly, your brain could make sense of the patterns being fed to it. The moment you think of a fire-truck, the device would understand that thought, and feed all of the properties of a fire-truck back to you, instantaneously fetched from the internet.

Also it would be ideal not to surf pages anymore but retrieving the data directly from the resource as you think. This way the internet becomes an extension of the human brain, like a portable hard drive for a computer. Seamlessly integrating with the users memory. How would it be to have wikipedia in your brain?

Let's elaborate on the possibilities with BCIs as it is the most direct connection between brains and the internet.

3.7.2 Optogenetics

Optogenetics is a fairly new technique and best suiting for reading and writing to the brain. By altering the genetics of individual neurons in the brain scientists are able to see and alter the state of individual neurons with lasers.[(Chorost,p. 120)]

By inserting a controlled virus into the brain, certain neurons will be

genetically modified and will make the neurons light dependent. This allows the spikes of neurons to be controlled and read by light. [video][1]

This is all theoretically possible already, but not tested on humans yet. From the practical perspective, scientists need to find a way to make it easy to implement this.

3.7.3 The internet as an extension

Let's refer back to the metaphor of the hammer. Often a tool is meant for one goal, but the internet got quite diverse in it's functionality. So in order to make it a more precise fit we need to look on both the internet and the human brain it's strengths and weaknesses.

Memory

Let's see what's more capable of storing lots of data, the brain or a computer. There's lots of speculations around the total size of the human brain translated to digital terms. Estimations vary from 1 Terabyte to 2,5 Petabyte (2500TB). (Paul Reber, 2010)

The big advantage of a computer on terms of capacity is it's ability to scale. Produce more memory, get more storage. The total filesize of the internet for example, grows exponentially. It doubles every 5.32 years. [Zhang, 2007, p. 6][#Zhang:2007]

With humans this is different. Although the human memory is scaling as well, it's more a matter of evolution and thus grows very slowly.

Also in terms of storage the brain is different. The brain keeps track on what memory is more important and what not, it stores data in hierarchy. The more important memory have more and thicker connections than others. (Hawkins, 2004, p. 133) Memory's are forgotten if they are not being accessed often enough. Also there is the transition from short-term to long-term memory which requires a certain threshold in strength of the memory. (Swaab, 2010, p. 555)

Computer hard drives, in contrast, store everything you want for you. No matter how important, no matter how long as long as you can translate it into bits and bytes.

In terms of scalability in size digital memory is the winner. Where digital memory is expandable and in terms of total internet size exponentially growing all the time.

Computational power

> Neurons are quite slow compared to the transistors in a computer. A neuron collects inputs from its synapses, and combines these inputs together to decide when to output a spike to other neurons. A typical neuron can do this and reset itself in about five milliseconds (5 ms), or around two hundred times per second. This may seem fast, but a modern silicon-based computer can do one billion operations in a second. (Hawkins, 2004, p. 127)

> No matter how many workers you hire, the problem cannot be solved in less time than it takes to walk a million steps. The same is true for parallel computers. (Hawkins, 2004, p. 130)

Try this: How much is 12345 times 54321? While you're grabbing a piece of paper and a pen, the computer already gave the result in a millisecond: 670 592 745. The computer is made for making linear logical calculations like this.

To be able to make calculations like this doesn't make a computer intelligent. The computer is programmed to do calculations like this, but didn't think and programmed it themselves. Hawkins predicts that computers will never be able to think of themselves, that there's no future in what we call artificial intelligence. His argument is that they can't reprogram their complete own workings except for some small parameters (which are programmed in advance) and thus are not intelligent, like us humans.

Because of the brain plasticity, described above, people are able to 'reprogram' themselves. Any input and/or conclusion is changing the internal structure of the brain and making the brain more intelligent. This is also called learning. Computers are not able to learn. There is this thing called machine learning, which is used to make predictions, but it will never be able to stop it's main task and completely rewrite it. Sure you can make really sophisticated machines and behaviour, but it won't be able to quit it's job as a computer and continue on as a butler.

A good example of the power of computer calculations is computational knowledge platform Wolfram Alpha. It allows you to do advanced mathematical computations, but also analysis over big data sets on the internet.

A conclusion you can draw from this is that computer is meant for linear tasks, where humans are way better at doing the non linear tasks. So, the computer is perfect for making advanced calculations like they do with the Wolfram Alpha platform. If you look from the tool perspective, this is one of the things computers are made for, making it an advanced calculator with a simple interface.

Sharing

One of the main functions of the internet is telecommunication. It allows people to communicate and share data with each other. But is the internet really so useful for communication?

The only way for a human to share the information is in the form of a conversation and writing. We don't have the ability to make connections with other brains like computers can. A conversation can be done over the phone, but the information has to be explained before the receiver can make sense of the data.

With computers you can just send documents, images, sounds or videos to another computer without the need to explain the information and at great speed. Imagine how long it would take to read the whole wikipedia (18gb) [Kiwix, 2013][#kiwix:2013] for somebody else. The in advance defined standards of the computer really help here. Because computers expect data to be formatted in a specific way, they can make sense of the raw data. Much like it would be to feed the stream of data coming from your retina (eye) to another human brain.

Roundup

If you look at internet as an extension of the human brain it needs to extend only certain functions. For instance calculations and sharing are the points the computer exceeds the power of the brain and it's logical to make them the main function of the internet. The brain is good for drawing conclusions by connecting the dots.

4. Vision

Now that we looked at possible optimisations for the communication chain
we can plot out a timeline for the future. What will be the next rough
steps?

Let's try putting the optimisations on a timeline.
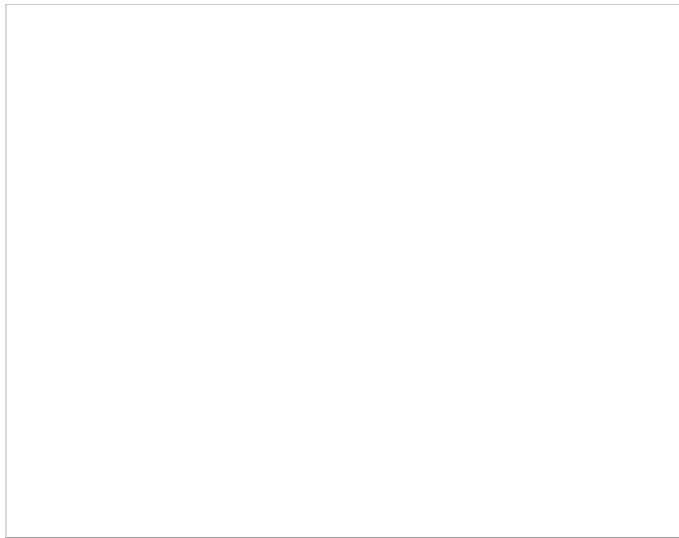
5. Conclusion

It's impossible to predict the future. You can only guess for the most likely possibilities. We think that Brain Computer Interfaces, optogenetics mainly, are the long term solution to the cluttering of the communication chain.

With semantics being crossed out and the need for GUIs as long we have screens; we think the most likely short term optimisations would be with alternative inputs like with Leap Motion, MYO and voice recognition. Also a small first step is to be achieved with removing the processing layer towards the facilitation of Brain Computer Interfaces.

Wearable interface will also facilitate the transition from traditional interfaces like the desktop computer to body integrated interfaces like Brain Computer Interfaces.

Imagine how a better connectivity with the information on the web could facilitate the sprouting of new ideas. New ideas and hypothesis sprout after getting new information/data. A new idea or hypothesis always is the combination of two pieces of information. A beautiful example: a 15 year old boy called Jack Andraka got an insight after reading a web page connecting the facts from those page to his biology lesson that day. This insight lead him to a hypothesis which made him find a way to test different sorts of cancer in a fast and effective way. (Nosta, 2013) All of this because he found a link between two facts and and saw a connection. What if we could facilitate this discovery by the optimisations we gave?

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