

HOW I LEARNED TO LOVE RFID

WORKSHOP BY HMKV, DORTMUND AND RIXC, RIGA
MAY 20-22, 2006



WORKSHOP OUTLINE



by Francis Hunger

Development of RFID

As many other technologies, which are basically used in the civil sector, the basics of RFID were commissioned and developed in the frame of military research. In late WW II the British Royal Airforce used „tags“ on their planes to decide whether it was a „friend or foe“ signal that was reflected by radio waves, used in radar technology.¹ RFID uses a similar basic concept. A radio wave is sent to a transponder – more commonly called „RFID tag“ – which then wakes up, consumes the energy of the initial radio wave and sends back data to the sender/receiver unit. Through the 1950s to 1960s, this concept was developed into electronic anti-theft devices that were in fact 1 bit RFID tags. They could be set either on or off and would signal if a person has paid and the cashier did subsequently deactivated the tag. So the theft alarm devices that are positioned on each entrance/exit of shops are very basic RFID readers.

In the 1970s several patents for RFID applications were issued and passive and active tags were developed in the private sector and in military research.² Today they are intended and used basically for supply chain optimization in logistics.

RFID and Surveillance

Discussions on surveillance are a long term issue of the civil society. One of the basic reactions on the introduction

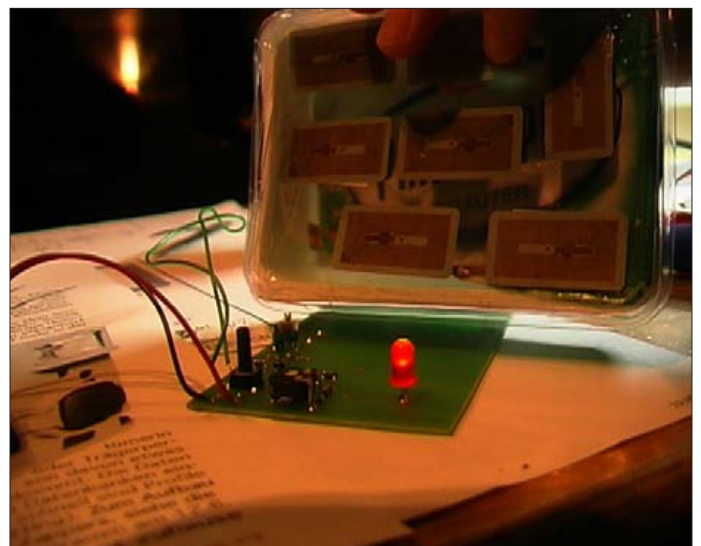
of new, publicly unknown technical devices was the fear of a heightened surveillance, be it with computers, computer networks, video, mobile phone or GPS. The military origin of most of these devices additionally fostered fears of governmental surveillance. In leftist movements and communities surveillance was and is discussed as a means of governmental suppression. Things over the last years appeared to be more complex, as for instance CCTV is not only run by local authorities, but much more decentralised by private busi-

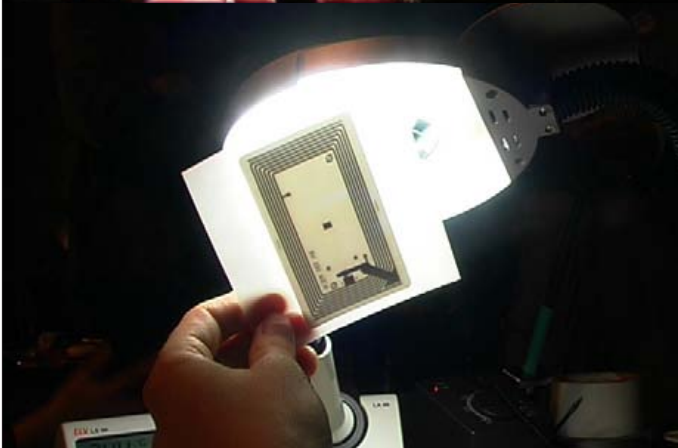
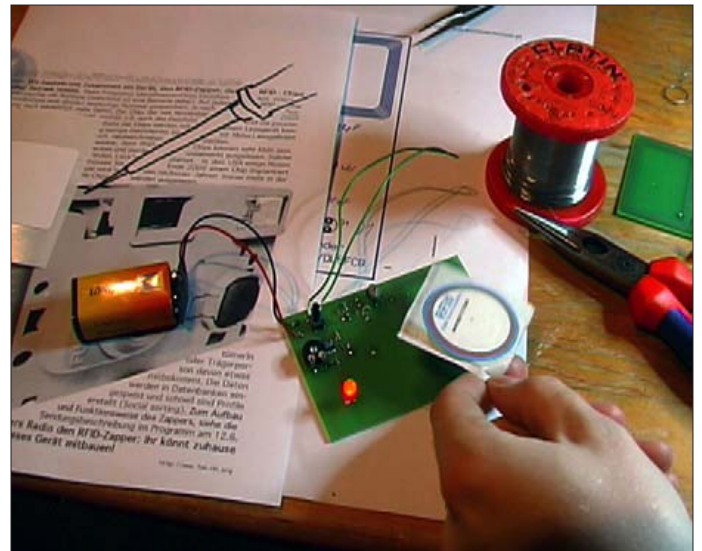


A FEW SCREENSHOTS



by Dorothea Carl





nesses. Another issue regarding the fears of a centralised super-surveillance is, that the huge amount of recorded data, be it video, e-mail, telephone calls etc, can not yet harvested efficiently by automatic, computed means.

It also appears that in addition to governmental and commercial surveillance the introduction of minimized digital cameras, especially on mobile phones, leads to an additional sphere of control. Potentially all private/ public spaces, e.g. techno parties, beaches, public parks, are kept under surveillance by their users themselves. You might get drunk and drugged on the techno party last night, dancing on the table and so on and find your pic in some weblog on the next day.³ Self surveillance and self control are fostered through the ever ongoing documentation of any kind of social gatherings.

It is obvious that surveillance thus gets another dimension, shaped by the interests of different social actors – governmental, commercial, and social.

🌀 RFID and optimization processes 🌀

The process which we experience as globalisation on a technological level relates a lot to what is called new media – satellites and the Global Positioning System, decentralized data transfer networks, real-time multi-media computer, mobile communication devices.⁴ Growing global real-time communication networks enabled optimization processes on several levels. First the communication itself got more efficient. Data can now be delivered on a global scale within minutes, where it took weeks or months before.

Faster communication allowed optimization on another level: Capital becomes on a large scale independent of national borders and namely the supply chain got optimized, to deliver materials or goods on demand. In these post fordistic production processes further optimization is an important issue, either through rationalisation or lowering personnel costs. Interestingly in this process of optimization, workers (who are potential consumers) are set free. At the same time it is getting more and more difficult to develop remarkable

sales markets for consumer goods because the large-scale employment rooted in fordistic industrial production vanishes (at least in Northern America and Central Europe).

The dynamics of economy and markets is based on their social actors as well as on the availability of efficient communication networks. RFID in this context in my opinion acts as another optimization tool. It is not meant to be used as surveillance tool against single individuals in the first instance. But if the needs of the capital to optimize supply chains or to control individuals call for its use, it will be used.

☞ Workshop ☞

While the technological „hardware“ can be considered as more or less ignorant to social issues, the software that runs the data exchange between several hardware devices is not. What Inke Arns called the „performativity of code“⁵ and what found its expression in software art shapes the way how technology works. Programmers (and programmer teams) implicitly inscribe their ideas of social hierarchies, gender-relations, economical standards⁶ and so on in the program code. To recognize how RFID is related to other technologies, it is just a first step to understand its basic technical function. The more important step for understanding RFIDs impact, is to get an idea, how it is integrated with other technologies (e.g. GPS) and how data is transferred, processed and stored through inter-operational software. The hierarchies of access to this data determine the hierarchies, which the (un)aware users get exposed to.

GPS and RFID and logistics-software are part of the ever ongoing optimization processes which at least from an economical perspective shapes society. On a cultural level software, which is being written by individuals determines the use of technology like GPS and RFID. For the workshop, I think it is worth to investigate a lot into the relation of software, their producers and the hardware.

(March 8, 2006)

FOOTNOTES

¹ Sir Robert Watson-Watt is credited for inventing the IFF Mark III system (Proc, Jerry: ASDIC, RADAR and IFF Systems aboard HMCS Haida, 1997, <http://iproc.ca/sari/sariff.html>, downloaded on March 4, 2006)

² The History of RFID. RFID Journal, Melville, <http://www.rfidjournal.com/article/articleprint/1228/1/1>, downloaded on March 4, 2005

³ eg. here: http://www.technohardbeat.net/pics02/080803/tm_78_ip2.jpg, taken in 2003 and as of 2006 still online.

⁴ Most of these technologies were basically shaped between the 1940s and 1970s.

⁵ Arns 2004: Texte, die (sich) bewegen: zur

Performativität von Programmiercodes in Netzkunst und Software Art. In: Inke Arns / Mirjam Goller / Susanne Strätling / Georg Witte (eds.), Kinetographien, Bielefeld 2004

⁶ cf. Hunger 2003: Computer als Männermaschine. Leipzig 2003, manuscript



NOTES AND QUESTIONS



by Jasmina Tesanovic

Because I come from Belgrade, I have had many identities in many tracking systems. I changed four official passports without ever changing my home address. Today, Montenegro split from Serbia. So I ask: if the internet of things comes into existence, will it be a force for order and integration, or for disorder, war and lawlessness?

As an activist in the informal Woman in Black network, I was blacklisted from the very first days by the police. I believe I am under surveillance today, if not by the government per se, then certainly by right-winged parties and other informal power structures. We Women in Black are an informal power structure ourselves. Our invisible dissident network was active in spreading news, smuggling refugees, deserters, medicines... and visible by publicly protesting against the criminal regime with standings and performances.

Police informers were the main source of information on our activities, meaning a network of diligent citizens who wanted to save their own necks or curry some favors from the regime. These informants were our neighbors, our friends, even our own parents. Often these collaborators and informants lied and deceived the regime in order to protect us. How would that activity translate into an internet of things?

Ten years ago, a paramilitary network, the Scorpions, carried out genocide in Srebrenica. Recently I have been in their courtroom where the Scorpions are on trial. My informal network and their criminal network are literally living together, on two different sides of a bulletproof glass partition. Suppose they had a paramilitary Internet of Things. Suppose we had a civil-society Internet of Things?

We are already mixing and mingling.

We have the same past, it is a small courtroom. What is Serbia today but an extended courtroom, with too many criminals to be found and sent to Hague, too many accomplices to be found and charged, and too few Women in black to find the mass graves and tag and identify the dead?

Perhaps if those dead had hidden some arphids within them, we could trace their dismembered bodies. So as to calm the pain of the families, follow the moves of the killers, and map out a locative history. That networked map of crime, drawn from the facts on the ground, would certainly differ from the official maps and borders that were drawn up in the Dayton peace treaty.

If we women, deserters, refugees and dissidents had this technology, would it increase our ability to survive? Or would it make us even easier to trace, track and kill? What kind of war is enabled by an Internet of Things and who could survive such a war?

During the first days of bombings of Serbia in 1999, I managed to post my diary out to the world, thanks to communication networks that were inside Serbia but not of Serbia. Networks like Opennet.org, Zamir.net... Those stories had my name attached as a tag, and since I was visible as a social actor, that name protected my life. At another moment, though, somebody removed my name from my testimony, supposedly in order to confuse investigators and protect me. Am I safer in the glare of publicity, or safer in anonymity, and hacking, and deception and subterfuge? Did Anne Frank ever enjoy her glorious afterlife as a famous diarist in troubled times?

I can sum up my doubts in one thought-experiment. Consider the NATO air raids. If the weather is good, the NATO pilots will see us clearly, and target us more precisely. If the weather is bad, the pilots will see poorly in the fog of war and drop their bombs on us at random. Which of these situations saves our lives?

(May 22, 2006)

A STATEMENT ABOUT THE WORKSHOP

by Rob van Kranenburg

The workshop for me was a major confrontation, or another stepping stone towards – defining my position: how serious is RFID as the glue towards digital territory and how to act, or rather when to act and to act how? The more I think about it the more I feel that the hard ‘no’ position is futile. RFID is an answer to the four building blocks of infrastructures today: on the level of code it is about distributedness, on the level of node about the need to individuate on item level, on the level of link it is the glue to the pervasive computing world and on the level of network it enters a political realm which has defined terrorism (by nature steeped in secrecy) as its major socio-cultural world view. RFID fits all these le-

vels like a glove. You might find an alternative to each level. You will not find an alternative that does what RFID does for you on all four. And if you do, surely not as cheap. So, RFID is here to stay. Then what? The logical thing to do is to raise awareness. But of whom? If we take the networked reality seriously then the public is gone with the central nodes in the network. Networked audiences have taken its place. This means that strategies aimed at 8 o clock news publicity might one day actually get there, only to find that ‘the’ public will not respond in an appropriate way. The industry as such is not convinced and through marketing labels as NFC, M2M, smart cards, it shows that it feels not at ease. The individual ‘I’ needs at least five to ten years (if we can extrapolate sensor sensibility to internet/browser sensibilities) to grasp that his or hers counterargument to our privacy debate (whether RFID or smart surveillance cameras): “I’m not doing anything wrong, so why would I care?”, only makes sense in an analogue environment. In a digital environment – no memory loss, intricate datamining, serendipity as default – the question is: “What might be deemed wrong by whom in power three years from now?” surely quite a different set of assumptions. So what to do? If a ‘no’ is a loss of energy, though a balance to the industry, if sparking a debate is a loss of energy, though a process of education large numbers of people, I can only see one course of action that takes all scenarios (utopian and distopian) seriously and that is building our own mixed reality nation. This gives sense and purpose and positive energy to our young hackers and idealists. Poets, after all, are the true legislators of the world. Makers too. Come to our county, now you see us, now you don’t. Doesn’t that make you smile? Come up and see me, make me smile. I’ll see you when you get there.

(May, 2006)

A SHORT STATEMENT ABOUT THE WORKSHOP

by Bruce Sterling

This workshop was very edifying. I’ve been working in this field as a design journalist and teacher for three years now. I was never so close to the grain of the material as I was in Dortmund. This was a beautifully timed conference with remarkably interesting people doing something genuinely new. I left it with the strong feeling that the mists are lifting and there are profound new opportunities at hand for art, technology and society.

(June 1, 2006)



REPORT



by Oliver Leistert

Introduction: Dortmund

Dortmund, a city with roughly 600.000 inhabitants, is located right in the heart of Industrial Age Dwelling Conglomerate „Ruhrgebiet“. Since most of coal and steel production has terminated here, vast areas of industrial ruins are left over. Some have been dismantled, some declared memorials of a gone age and some have been remodelled for new usages. This is the case with the PHOENIX Halle, which was part of the huge PHOENIX areal, a furnace site, where one can easily still be impressed by an rusty industrial monster of double soccer field size. So, place is not scarce in Dortmund. Not in and not outside the PHOENIX Halle. The Hartware MedienKunst Verein (HMKV) has full access to the hall and any exhibitions there will definitely not lack space. But maybe this place could be promoted better. When I arrived with my colleague at Dortmund Hauptbahnhof, the taxi drivers either wanted to bring us to some other hall or had to admit not having a clue about the PHOENIX hall and its location. This seems to be a symptom that art and culture in the Ruhrgebiet suffer from: interest by locals is small. This might have a myriad of reasons. One trace might be that unemployment and populist media have changed the traditional „red“ area of the Ruhrgebiet into a region with more and more rightwing and explicit nazi activities, letting popcultural mainstream turn right as well. Last year, one punk was murdered right in the center of Dortmund by Nazis. Any art institution in Dortmund is confronted with such phenomena and has to react upon them. Maybe this is why HMKV organised a big exhibition about globalized football. In the midst of World Cup tohuwabohu they present uncommon views on the multi-billion dollar business of football.

The 1st day

The public day – saturday – offered a dense set of lectures. After curators Inke Arns' and Francis Hunger's introduction, Bruce Sterling, well known sci-fi writer, now more and more into teaching, gave his keynote. He started with a high-speed travel through contemporary ambient/ubiquitous computing/web2.0/networked objects. Proposing „thinglings“ as a proper term, he recalled the main issues of coming objects: chips with ID's, GPS/Locative Media, Search Engines, Recyclebility, Virtual Models of Objects. As guiding principle, he proposed, it would be helpful to think of material instantiations of immaterial objects that will surround us soon. Bruce announced with a slightly cynical touch a „seven year window of opportunities for artists“. To differentiate one from cooperate sites, he proposed to write „Rphid“ in html-meta tags, to identify interesting RFID-sites and projects much easier. His tour de force through contem-

pary discussions around networked objects open the field for the whole day of speeches very wide and set expectations high that the follow-ups would use this discursive space.

After this most entertaining presentation, the FoeBud people from Bielefeld, namely Rena Tangens and padeluun, startet their show. FoeBud's point about RFID is privacy. They presented some success they had with interventions such as against Metro's RFID containing consumer card. The limits of Foebud's political discourse are that they have an isolated view on Privacy and Data Protection by recalling idealistic democratic narratives. To isolate questions of information protection from wider discourses such as why the cooperations are the players and who takes the benefit from such a technology like RFID make FoeBud's political claims blind against the trajectories it may lead to: initiatives like FoeBud help to make surveillance technologies compatible to western democratic regime standards. Foebud is not radical in any sense. Their primary concern is: citizens should decide what electronic information about them is held by whom and have the right to access this data and delete it. So, for instance, if consumer tag RFID once will be designed in a privacy compliant way, Foebud's aims are reached. In this sense, they offer consulting services for free to the industry and governments. That these players don't want to accept Foebud as a partner doesn't mean Foebud's work isn't of any use for them. Historically, these Bürgerinitiativen-like associations of concerned citizens have played and will now and then play an important role as an catalysator during the implementation of new technologies into society. The second critical point I may sketch concerning Foebud is that their political model depends solely on representation: they act like the lobby of citizens. But what if citizens don't care and are happy to use the customer cards? This leads the most problematic field of political action itself, when you have to ask yourself whose voice you are raising and what you do with that. In the IT for Development discourses, these questions are debated highly. Sadly, this discussion has not yet reached the Foebud people. Foebud has to ask itself: what concepts of society are used and what are fictitious parts in that image of society. If one has to refer to the Shoah when talking about the RFID World Cup Tickets, something is terribly wrong!

After the desperately needed Lunch Break (yummy!) agency agent Rob van Kranenburg presented a „weired“ (Bruce Sterling) presentation of a different kind. Rob concentrated on an European perspective of information spaces. While nation states loose more and more their sovereignty to the European Union, the E.U. itself urgently needs an information space for its citizens (this is what I understood as one of Rob's claims). RFID plays a role here, as it is amongst those technologies that constitute and operate in information spaces. To design these spaces according to the needs of E.U. citizens is one of the tasks Rob informed us about.

He claimed a „design for emergence“ as default in systems. Meaning that design of technology should right from scratch be an interdisciplinary task, not solely of engineers and economists. Otherwise RFID would rest in the deadlock of hostile digital environments vs. consumer/citizen needs. Besides that from my perspective, that I find it confusing to demand such implementations within the E.U. as it is anti-democratic monster, leading in a constitution proposal that wants to implement free trade and other market ideologies as default on constitutional level, I have to admit that I have not the slightest idea how someone should even approach the E.U. bureaucracy. Do they organize hearings for concerned citizens or letterboxes where one can drop wishes to the Commission?

Following Rob, Wolfgang Lammers of the Fraunhofer Institute in Dortmund, gave his speech. This was again a difference! Wolfgang presented actual and future targets of RFID in logistics and the problems thereby. He went deeply into explaining technical matters and systemic explorations. There are advantages with RFID against the Barcode or the 2D-System (a printed code, containing more informations than the barcode, being much cheaper and more easily to deploy than RFID). But the main problems with RFID still seem to be costs and non-faulty operationability, as fault readings would cause dramatic follow-up costs in any warehouse.

Rasa Smite (RIXC, Riga) and Honor Harger (radioqualia) then reminded us that Radio doesn't necessarily has to be small, but can be very big. The Riga Center for New Media Culture (RIXC) has hands on an ex-Soviet radar system, that once spied over Europe and was abandoned when the Soviets left the baltic countries. Together with local astronomers the artists took over the system and are now listening to nothing less but to the radiowaves of the sun and other astral objects. This was then experienced later on in the evening, when a live broadcast from the sun was transmitted, with interpretations by sound artists that were present in Dortmund. In a way, this raw and fuzzy end of the day was a good closing. It symbolized to me that talking about RFID needs to be focused and centered on concrete implementations of technology into society.

☞ The 2nd day ☞

Sunday, the „hands on workshop“ started in the morning. The FoeBud people had brought with them material and tools to build some RFID gadgets. So, the whole bunch of artists, writers and how we call ourselves, tried to build an RFID-Chip detector (a project originating from german computer magazine c't) and an much easier to build RFID-Reader detector. Unfortunately, some parts to build the Chip detector were missing. So we succeeded only partially. But everyone seemed happy to do something with their hands and touch electronical devices.

In an afternoon discussion all participants discussed the sad and not very impressing artistic use of emerging technologies such as RFID. Besides beta-testing, we could not state many ideas pushing technologies somewhere else. The „we make money not art“ site seems to be paradigmatic.

☞ The 3rd day ☞

The next day, we met at the Fraunhofer Institute for Logistics and Materials Flow, located near Dortmund's University. The staff gave us a long guided tour. In their warehouse-simulation-like lab, we learned that RFID is efficient and makes everything even more efficient. One highlight I remember: Everyone is a logisticist!

☞ Conclusion ☞

After these three days, it came to my mind that I recommend to strengthen focus when discussing RFID. As a technology, it is easy to understand. But as a part of society, its manifestations are manifold, depending what purposes it is being used for. On a general level, one has to remember that RFID is basically just one more brick in the wall of quantification. With RFID, counting and sorting are default. So, anywhere it will be deployed, economists are capable of calculating. For an artist, who refers by her name to an poetic world, this might at least provoke some reaction. Digital surroundings have systemic limits. By setting these surroundings as default for society, non-intelligible, non-countable and non-economised fields are losing even more weight than they already have in a functionalist capitalist surrounding. RFID in this sense is a hegemonial technology. As the Fraunhofer staff told us: it is all about efficiency. This is the imperative of capitalist ideology. If you are not efficient, you die. Let us think in this direction and forget about RFID-toys. Or, as the Critical Art Ensemble recalls in their latest book „Marching Plague“ to spot uselessness as a ghost haunting the functional world: *„We find uselessness even in the most functional of items, such as simple and complex technologies. Technology is generally considered a practical, material formation. Sometimes its tendency is utopian, sometimes apocalyptic, but it is always assumed to be functioning instrumentally. In truth, instrumentality's opposition very often creeps into the techno-object. From low-end instruments like cell phones jammed with useless features [...], to the many overly specialized pieces of low-end technology that clutter the closets of the middle class, to the highest-end germ and nuclear warfare technologies, uselessness is an integral part of each. When has the intercontinental ballistic missile ever been used?“*¹

(June 12, 2006)

FOOTNOTES

- 1 Critical Art Ensemble 2006: the Marching Plague. Germ Warfare and Global Public Health. Autonomedia 2006, p. 86



FOEBUD: HOW WE LEARNED TO STOP RFID



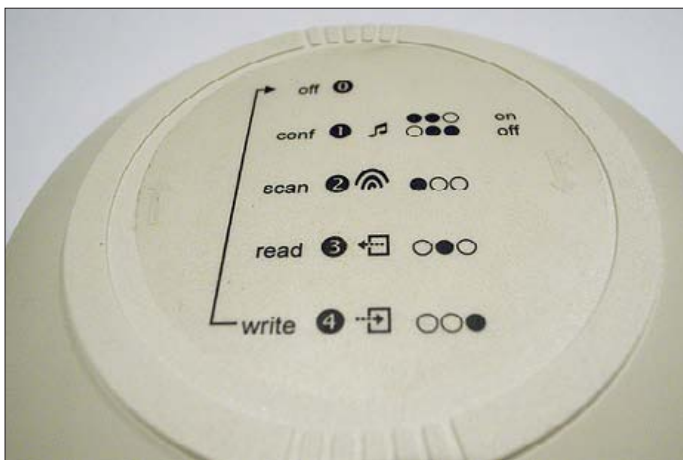
By Timo Arnall

FoeBud are a German group of privacy activists that has a long history of public interventions in privacy and RFID. Rena Tangens and Padeluun presented their work at the recent workshop *How I learned to love RFID* at HMKV in Dortmund. This is a brief writeup of their talk and the issues raised during a day of practical explorations with RFID electronics.



Stop RFID logo

In the past they have organised the Big Brother Awards, and Stop RFID campaigns at high profile industry events. They have gathered momentum in public opinion, to the extent that many German retailers and manufacturers have had to change their policy on RFID usage.

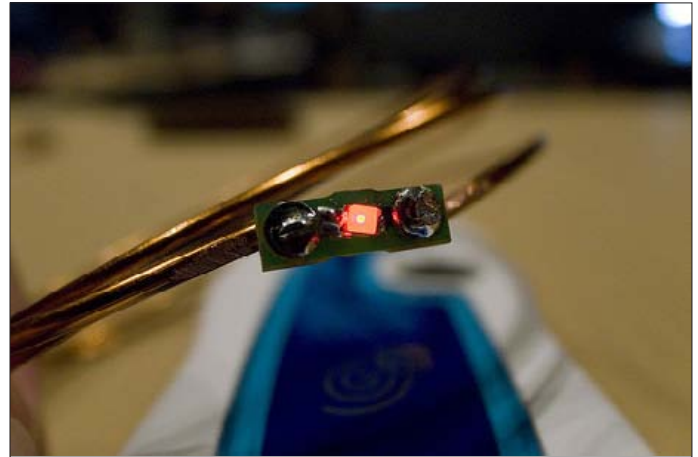


The FoeBud data privatizer can read, write and copy RFID tags.

They have probed the issue of privacy with such actions as printing personal information on personalised t-shirts to understand why there is a general lack of knowledge about the valuable data that people willingly give up. How do people

feel about walking around with their marital status, passport numbers, age, address etc. in full public view. This is somewhat related to the experimental project called Loom by Livework about personal information and value.

They have also created a set of scenarios (in German) that probe the potential misuses and problems with RFID and tagging of things. As a design exercise these are really creative and interesting. They have also apparently had a large effect on public opinion of RFID.



Detecting radiation from the Nokia 3220 NFC phone with FoeBud's bracelet.

In one large intervention they invited Katherine Albrecht to visit the Metro future store. The Metro group is exploring advanced uses of RFID on the customer side of the supply chain. They are using RFID enabled DVD covers that act as physical tokens for movie trailers on an in-store screen. On the surface this seems like an intuitive example of interaction design, but customers must also use their RFID enabled customer card to verify that they are 16 years or older in order to view the movie. This leads to concerns that the store is tracking the viewing habits of their customers. This is not the most pressing privacy concern, but what is problematic is the way in which the tracking process was invisible, the Metro group tried to hide the fact that they had RFID in the customer cards and were secretive about the technology involved in the process. Clearly this is not the way to roll out a new user-centred technology.



The FoeBud tagfinder.

They have also explored the upcoming use of RFID in the World Cup. In this case the organisers are using customers passport numbers to verify them: and embedding RFID into the paper tickets. What is interesting here is that it is very difficult to find out why they are using RFID, it seems that it's a large scale technology trial that is overly invasive, without any user-benefits.

During the workshop we created two electronic prototypes: an RFID reader detector and a tag detector. Both products are sold by FoeBud on their website. These are extremely interesting products: well made and useful. In the same way as NFC in mobile phones starts to offer end-users some control over RFID, their products start to give us an awareness of the emerging readers, writers and tags embedded in the environment and in objects.



Bruce Sterling solders surface mount components for an RFID 'Tagfinder'

These products seem like the first signs of an emerging market for tools that allow greater user-awareness of RFID. It would be useful to explore how we might embed such technology in other everyday products, or make more commonplace objects for detecting, reading, writing, copying and perhaps jamming.



An RFID reader detecting badge

Overall it's great to meet people that have a lot of fun doing the work that they do, they seem to get an enormous sense of satisfaction out of the triumphs they have over large industry. Although I disagreed with their presentation of RFID

as being uniformly invasive, it was great to see a group being so pro-active in offering ways for people to visualise and protect their own privacy.

You can buy some of their 'privacy enhancing' products at their online shop, look particularly for their RFID products.

(June 5, 2006)



BRUCE STERLING AT



'HOW I LEARNED TO LOVE RFID'

by Timo Arnall

On the 20th May, Bruce Sterling talked at How I learned to love RFID in HMKV in Dortmund, Germany.

He covers a lot of ground, including approaches to sustainability, artist use of RFID and proposed interventions, many of the themes from Shaping Things. When he lays out the potential for misuse, the use of RFID for tracking cocaine supply chains for instance, he manages to reverse our pre-conceptions in a very useful way. Some of these statements are deliberately provocative, and they usefully challenge many of the commonly circulated 'black and white' opinions about RFID.

This is an outline of the talk that is edited from a rough transcript. It's impossible to properly capture Bruce's words that pour out in a stream of tangible utterances, so any errors are probably mine. The talk started with perhaps an incomplete list of designers approaches to sustainability:

☞ 1. Collapse ☞

In this scenario we end up in the wreckage of the unsustainable. This is the grim meat hook future that many think we'll end up in.

☞ 2. Make less stuff ☞

In this scenario we have people that want 'a good design solution to every problem': permanent tyres, housing, etc. and no more planned obsolescence. A utopia that never changes. In this case the Amish may have done it, but no child ever agrees to their parents version of reality.

☞ 3. Biological or biomimetic materials ☞

In this scenario we use only biological or biomimetic materials: only materials that can be recycled or grown. But many believe that we can't survive without our current heavy

industries. This is an interesting approach but may be many decades away.

☞ 4. A sustainable internet of things ☞

In this scenario (that Bruce is proposing) we use RFID and green technologies to enhance our current material world. We have a chance to make a whole bunch of really fresh mistakes!

☞ About RFID ☞

RFID is currently being imposed from on high by DoD and Walmart. The 'RFID industry' rarely alludes to the larger picture: rfidjournal for instance sees RFID as a glorified barcode in the supply chain. But what about the Colombian use of RFID to track cocaine: there's your supply chain!

Books and references

Morville: *Ambient findability*. Searching the physical world: looking for a library application to go out and catalogue the planet // Greenfield: *Everyware*. Ubicomp is about the middleware: what is the browser of the ubicomp world? What should you do with ubicomp: what enhances peoples lives, what enhances dignity? // Garfinkel & Rosenberg: *RFID Applications and Security*. // Bleecker: *Manifesto for Networked objects*. // Sterling: *Shaping things*. // Weiser: *Calm, peripheral technology*.

☞ What are the important elements of the internet of things? ☞

☞ Primary attributes ☞

The lowest common denominator of the internet of things is a chip with a unique identity. Basically a file with a tag that is findable.

Local positioning systems: located, and histories of location.

Search engines: we've got to be able to find objects

Recyclability: have to do something about the end of the supply chain – a bit of economic value in junk. Some have negative economic value.

☞ Secondary attributes ☞

Virtual models of objects: the computer model is the first description of the physical thing. Immaterial instantiations of a material thing – 3D computer models at the start of the supply chain. At the end of the supply chain the practice of the object is still available – the history of the object is still available beyond it's physical form.

Rapid prototyping of objects: fabjects. Solid plastic and metal objects from virtual models are now possible.

☞ The future of RFID? ☞

We could have an RFID boom and bust. Once we have printable RFID ink, sprayable tags made from organic semiconductors without silicon, this thing is going to be huge, and we cannot police ink!

Ubicomp will not actually be about 'smart' objects: not about ubiquitous, intelligent computing but about ubiquitous tagging: the dumbest, cheapest, walmart fodder: it's about the everyday. Not about getting your fridge to talk to your cooker. There more of it there is in the landfill the more it needs tags. This is the war of the landfill!



☞ What is the job at hand? ☞

There is some overlap between the 'web 2.0' social phenomenon and internet of things (IOT), this is the most exciting time on the net since the invention of the browser. IOT is perhaps web 5.0...

☞ Four ideas of sustainability ☞

The Web 2.0 meme map from Tim O'reilly helped the idea of web 2.0 to pass into general parlance, it became a web nexus of social practices. Overall it was very ambiguous, not disambiguating, and described more of an attitude than a technology.

We need an Internet of Things meme map: The IOT theory object, we need great THEORY ENGINEERING: What are the champions, heroes, ideas, corporate strategic bullshit in this space. We need to include ideas of small objects loosely joined: geolocation, storage, bandwidth, information architecture, interaction design, participation, reality augmentation, standardisation, customer self service, user positioning, etc.

The Internet of Things cannot grow from anything other than the internet itself: created with linked ideas: linked objects will form and thrive on the internet: the objects will come from the exact technical substructure that created web 2.0. RFID has reached the level of popular mechanics, and people looking at the map should feel like they could take it all home and whip some together.

☞ RFID for artists ☞

Artists have a seven year window of opportunity. RFID at the moment is basically magic: the classic force of technology art. This might be a more interesting immediate use of RFID than the classic bohemian kick-back of protest: I've got RFIDs too. Until people get used to it.

Artists should use the term 'Arphid': to distinguish practice

from the haze of millions of blogs and RFID as barcodes in searches. This would help to define and establish an alternative community or practice.

☞ Interesting arphid artists / people ☞

Meghan Trainor: With Hidden Numbers // Mary Hodder: itags // Ulla-Maaria Mutanen // Semacode // Yellow Arrow // xbox Blogjects // Urban Eyes // Arphield recordings: tracking oyster cards // Katherine Albrecht

☞ The issue of privacy ☞

Of course corporations are tracking and tagging: Google is tracking and tagging everything you search and mail. Amazon tracks and tags: look at the 'page you made'! Every argument made against RFID now was made more eloquently against computers in the '60s. Verichip is trying to push the contradictions: releasing implantable chips for immigrants. These are 'Warholian' stunts, 'Yes Men' style interventions. Ubicomp is extremely potent. There is a lot of interest in geo-locative stuff at the same time: lots of journalists working in the same space. 'Sometime it's steam-engine time'.

☞ Questions and Answer Session ☞

IS IT POSSIBLE TO TELL THAT SOMETHING IS AUTHENTIC JUST THROUGH AN RFID TAG?

There will be intense effort to break RFID. It is the ideal hacker technology. With such limited physical means it's very hard to stop hacking and vandalism. The IOT has every internet problem, plus a million more. Because they are THINGS! Crashing will be a whole lot worse. A large surreptitious tracking community may emerge with the intention to take down and crash the system: it's possible. There are a million ways to hack an arphid, plenty of opportunities to wreck the technology.

IS THE ACHILLES HEEL OF THIS TECHNOLOGY THE HACKABILITY?

The Achilles heel is not the technology, but the 'spook aspect' in public opinion: moral panic. But the more people that understand RFIDs the less it will be possible for Walmart and Darpa to use it for nefarious purposes.

ARE WE NOT HEADING FOR A WORLD FULL OF MENTAL JUNK: MANAGING HUNDREDS OF BLEEPING OBJECTS?

It's a question of 'cognitive loading' how much do I have to think about this? One of the reasons that environmentalism has failed is it has too much cognitive load: the notion was that we would be mindful of our objects, and pay attention to using them thoughtfully or where they went once we had finished with them. The correct approach is to remove mindfulness from the system. Perhaps spimes could allow us to do something once and never think about it again. Want to move away from a potential obsessive compulsive thing disorder. From a 20th Century design perspective Spimes would be really problematic: too much upfront con-

figuration, categorisation and control. But on the web we are moving away from a 'sort then publish' model to a 'publish then sort' model. The cure then for 'mental junk' is twofold: a machine that gets rid of the spam, then a community that filters stuff for me. We want to do/make less with more, do more with data.

WHAT WOULD AN EFFECTIVE INTERVENTION WITH THIS TECHNOLOGY LOOK LIKE?

RFID is not going away, there's very little possibility of popular resistance, because it's being mandated by the Pentagon! A successful intervention might look more like Wikipedia: not sucking encyclopaedia Britannica dry, just a different approach.

(June 5, 2006)

ROB VAN KRANENBURG AT 'HOW I LEARNED TO LOVE RFID'

By Timo Arnall

This is a short summary of a huge presentation by Rob van Kranenburg on RFID issues, that covered many valuable topics including local activism, EU policy on ubiquitous computing, participatory culture and distributed computing. Rob seems to be someone that thinks many times faster than he talks, and has so many valuable things to say, that it's very difficult to succinctly summarise his presentation.

☞ Background ☞

Few people talk about genetically modified foods anymore, genetic modification is now something that is talked about in fashion circles as a creative technology. The field has taken about 10 years to get to the point where the discussion is no longer about ethics but about fashion. In the case of RFID, we are perhaps at the beginning of this process: RFID has become Smart Cards, Near Field Communication, M2M, etc. There is a huge re-branding effort going on, and there is little debate about using Smart Cards for public transport for instance. We are dealing not just with technology, protocols or standards: but a context: a deadlock between technology and the environment. From the technology of the pen onwards there has been tension about externalising what should be internal. Distributing information to the environment implies that we trust the environment.

But people have a deep, deep mistrust of the environment. It is also very hard to come to terms with something that has a 100% memory, we are all highly analogue. In an experiment to probe this mistrust *The Watch Out Team* was welcomed

to a small town in Netherlands: to watch out for everyday things. The enthusiasm with which they were welcomed was scary:

"The idea of this performance like intervention was to draw feedback of the kind that would get the joke, that would be aimed at the experienced top down disciplining process going on. What happened instead was far more interesting but also far more disturbing. Whenever they were approached with a question like what kind of organization are you from, they'd reply: the government. We are the Watch Out Team, a new government sponsored initiative. At the market where they dished out watch out umbrella stickers to grateful umbrella holders I overheard a daughter telling her mother: ,They should have done this much sooner!'"



☞ RFID and the EU ☞

"I will not see the liberty of citizens and their fundamental rights being compromised" – Viviane Reding

The EU sees RFID as a key technology that will shape the age of the Ubiquitous Network Society. RFID tags will be nodes in most future ubiquitous IT systems, and the glue that binds ubiquitous computing together. Behind this vision, they claim a strong social concern. Can this intention be upheld when we are in the midst of a 'war on terror' and RFID is a perfect candidate for tracking and control? But overall the EU seems to be doing a pretty good job of scoping out the issues of RFID, and aiming towards world governance of RFID issues.

☞ How should we deal with privacy? ☞

It is naive to say that RFID tags do not contain information, and thus cannot be linked to individuals: that disregards the whole history of data mining. Transparency is important, individuals should certainly have access to the information that their tags carry. This view has been fuelled by the Nokia phone that reads and writes tags. EMF leakage will also be a huge problem. One approach would be to specify zones for different kinds of sensors, how do we solve this visually? Digital territory, digital bubbles, various mediascapes, seamless technology, networked objects, etc. We need to

design for emergence: the behaviour of an agent cannot be entirely pre-programmed: we need to launch and learn. We also need better interactions and relationships, opening up space for more consumer control. Interestingly, and perhaps problematically, there is currently no competitor/predator for the ubiquitous computing model.

☞ Changing dynamics of society ☞

A digital network turns civilians into professional amateurs. We see a growth of informal networks operating between a formal policy level, and a idiosyncratic everyday life. As an example, the browser has drastically disrupted the dynamics of society, from house buying to local politics to personal relationships. We are seeing a revolution from below. We cannot hand over ubiquitous connectivity and expect people to stay the same.

To probe this, a scenario was created, depicting the death of the EU in 12 steps which shows that Europe is a dying dynamic. People are being more pro-active in local planning, new business models disrupting existing businesses (real estate for instance), and the localised tax system becoming increasingly irrelevant. It was particularly interesting to start to make this link between bottom-up, participatory culture and the distributed technologies like RFID.

☞ More ☞

Rob has just completed a report on RFID with co-authors Matt Ward and Gaynor Backhouse. It's a great overview of RFID technology and use: *"This TechWatch report provides a brief discussion of these issues as well as a detailed examination of RFID technology, including some of the current uses within research, administration and teaching and learning. The report also includes an overview of the significance of RFID as an enabling technology towards achieving the 'seamless' and 'calm' vision of ubiquitous computing, the role of the Internet of Things, and plots a future trajectory for RFID development within the wider context of wireless, networked environments."*

[Download the report here](#)

(June 11, 2006)

RFID, LOGISTICS AND MATERIAL FLOW

by Timo Arnall

On the final day of 'How I learned to love RFID' we visited the Fraunhofer Institute for Material Flow and Logistics.

The institute concentrates on supply chain, logistic and robotic applications. They also foster the Open ID Center, that intends to create open platforms for the use of RFID in the supply chain.

Logistics and supply chain applications are mostly out of the scope of investigation for Touch (Touch is a research project looking at the intersections between the digital and the physical. Its aim is to explore and develop new uses for RFID, NFC and mobile technology in areas such as retail, public services, social and personal communication). However, the discussion covered interesting areas such as the potential of RFID to offer a more transparent supply chain, that may have an impact on the ways in which we interact with things in the future. For this, it was very useful to get a deep insight into the 'other side of RFID'.



Conveyor

The form of the discussion was an informal talk with Ralf Neuhaus while observing the various testbeds for containers, palettes, conveyors and robots. Then a question and answer session with Hunika Nemeth, a software engineer working with Enterprise Resource Planning systems.

Background

The Fraunhofer people were very honest that they are still conducting basic research in RFID technology. Their focus is on the integration of standard components that form useful supply chain applications. They are creating prototypes and products around these integrations for their clients.



They aim for lean processes that are decentralised, distributed and transparent. This is inspired by MIT ideas about 'lean production' and Japanese thinking around management process. In their view, logistics shouldn't be seen as a discrete, closed, compartmentalised system: Everybody is part of logistics, we start to interact with these systems the minute we order something, or interact with daily life: the systems that order the food we eat, that manage the ways that cities run, that keep higher level systems such as transport running.

Are there new business models around this?

They have the intention of making an 'internet of objects' but they foresee huge problems when they move outside of closed systems. They predict that the true internet of things will not happen for a while. When an RFID supply chain is being designed, negotiation between partners is a critical problem area. Clearly trust is really important between partners, but this needs to be encoded in software and hardware. What if my competitors can see what is on the shelves in my warehouse? How do we balance co-operation and competition? They are trying to develop 'high end and low tech' systems, meaning that there is the use of off-the-shelf components (that do not require basic research) that used together offer new ways of solving problems.

How is an RFID system organised?

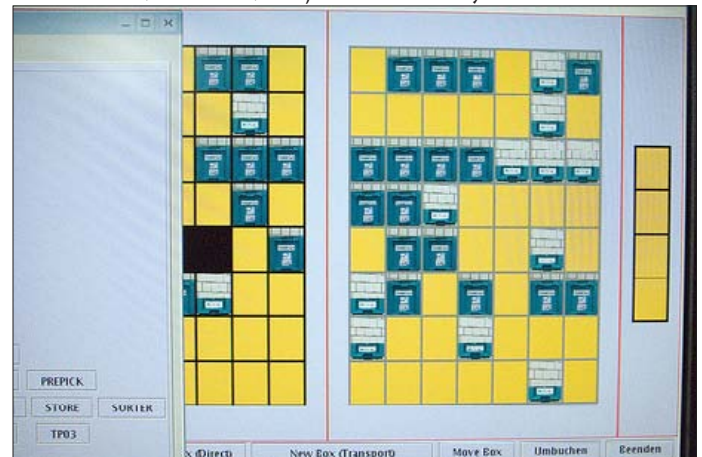
There are three levels to an RFID system:

1. An Enterprise Resource Planning system (ERP)

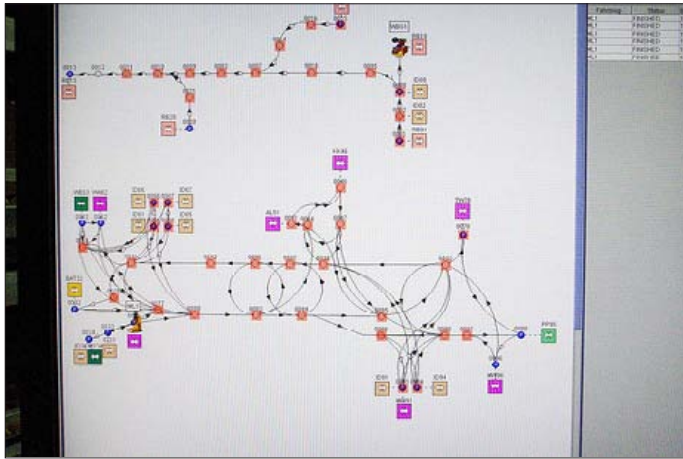
An ERP is a database that can be leveraged and queried at a management level. It is typically asked questions like 'how many goods do I have in storage?'. It can be queried about motion and velocity: how much goes in and out over certain time periods. It also links into other personnel, financial and material management systems, where staff, machines and economics can be planned. 30% of the ERP system is about relationships to suppliers and customers.

2. A Warehouse Management System (WMS)

This system has all of the information about the status of a warehouse, such as the movement/guidance of the vehicles, locations of palettes and items. All things (relationships, movements, contents, etc.) are historically recorded: a kind



of 'archaeological development': so that jobs or tasks are not done twice. The interfaces are on control panels and wireless handheld terminals as well as visualisations on large screens that include 2D plans and images, so that people can see with a glance what is going on. The WMS is usually tailored to customer needs, and this is what Fraunhofer have developed most themselves. It's connected to the ERP, but in some cases might be better off as a single system.



3. Middleware

Nobody really knows what RFID middleware is yet. It is something that everyone needs to use, and is developed in situated contexts according to very different needs. There is a huge challenge in that all customers try to integrate their existing software landscapes into an RFID system. RFID technologies are fundamentally different to previous barcode or signature based systems, in that they contain more detailed information as to history, ownership, value, time constraints, etc. plus the fact that we can read and write to RFID. This means that they are representational different in software. The basic affordances of the RFID needs to be represented in the two systems above. ERP system providers are working with Fraunhofer, and designing their own middleware. At the moment these providers are integrating their middleware into their customers systems. They are unifying many different chaotic things in the middleware. Each customer is different, they all have historically grown systems. Fraunhofer tries to make lean middleware, to accept different data streams and to get them into unifying languages. Middleware shouldn't know what will happen with this data, it just routes data between systems. The leaner the software, the easier it is for the customer to integrate it into their legacy systems. What is interesting about this is how layered the systems are at all levels. Objects know where they need to go, and don't need warehouses to tell them. Systems are layered into local levels. Things get pushed to higher levels when needs arise: not central authority, but local reporting. Like blogging! Yet in all cases there seem to be exceptions, and apparently in some special cases, the transponder can go directly into the WMS or ERP and change the direction of the conveyor.

☞ What about hardware? ☞

At a basic level there is only the use of RFID readers and RFID transponders (tags) of many different types.



RFID gate

RFID readers are organised into 'gates'. There is not yet a technology capable of scanning an entire warehouse and working out what is there. As the ERP needs to know whether to put the objects on the plus or the minus side of the inventory, these gates cannot just read the IDs, they also need to know whether the items are going in or going out. RFID transponders are passive and active. Again we see interesting layering of responsibility. Packages or items contain passive tags that communicate to a gate, and the gate then writes an active tag on the palette so that it knows what it contains. This overcomes some of the problems with reading passive tags over long ranges.



Active pallets

Within logistics there is an economic factor: if the product is high-value then it makes sense to have sensors and active tags to track things like temperature limits or shock damage. Active tags used for these purposes can be switched into passive and back again to save battery power. In typical environments they last for about seven years, and do not have replaceable batteries! On the tag we can store 256 bits of data such as time labelling alongside sensor data. As soon as we have temperature and other measurements then it gets more complicated, particularly integrating the data into the database.



Active tag

There are also interesting investigations into material handling, such as parcel sorting using distributed intelligence, and grabber technologies that can handle just about any shape of object through the use of rotating rubber bands.

☞ How are you thinking about security? ☞

Security has mainly been a question of whether the objects are online or offline. Fraunhofer have been developing intranets where certain permissions are given and shared between suppliers and customers, this is perhaps a more traditional question of access privileges.



UHF ceiling reader

But when it comes to RFID transponders and readers, the security question is more open. There is no established rules yet about the permissions structure for transponders: who is allowed to read the transponder data? Who is allowed to write over the data? For each customer the question is different. In pharmaceuticals for instance they need very strict documentation of processes, there must be no permissions for manipulation, what is written on the contracts must be fulfilled, and transponders and readers must obey this. Then there are material security questions, such as the kind of 'logistics of goods that you use more than once'.

There is always loss, even in closed systems. In one year a typical logistics firm will lose about 30% of their containers: they are re-appropriated for other purposes. This is

experience from everyday life and must be encoded into the software systems.

☞ What about the internet of things? ☞

There is pressure from industry to put everything on the internet, which is difficult from both a security and management perspective. If we put a transponder on every product then we will have data-overload problems, even if we are running local servers. Future intra- and internets will need to be powerful, scaleable and high-bandwidth.

Fraunhofer runs a project that asks what will happen if everything has a transponder? If we take yoghurt pots for example. We have 1000 yoghurts on one two metre high palette. Where do we put all of the transponders? The gates typically break down after 150 IDs, and it breaks down at the level of physics, not software. But should we solve this problem? Is it important? If we solve this, then perhaps the middleware becomes too overweight. This is then not sellable, because the software will be too complex to integrate into legacy systems. The ERP could then be overloaded, and would require a huge management task. At this point many of us in the room shouted out that of course it will be solved! If we look at Moore's law, the history of technology, mobiles, laptops, wifi, etc. it all seems to work on desire. The Fraunhofer people partially agreed, but re-iterated that there is a problem with physics, not software. At a certain point hundreds of tags pulsing is indistinguishable from background radiation.

☞ What about printed electronics? ☞

At the moment it's not even possible to get a prototype of printed RFIDs from the research labs, so it hasn't yet been possible for them to test out the technology. Maybe in 2 or 3 years printed tags will reach the power levels that the silicon/metal/soldered labels currently in use.



RFID printer

There is still the need to develop the right polymers for use in the printing, at the moment the base-material in many of the polymers is not activated by UHF radiation, making it useless in current reader systems. And then even if we have the polymer transponder: there are still huge infrastructural

developments to make it work. Until the right material technology is found we can use the experience that we gain with non-printed tags. In order to reach the internet of things Fraunhofer wants to try to integrate tags in packaging. When people talk about RFID they often refer to the 3 cent goal for the tag, but if we look at the whole picture there are also other printing, moving and 'sticking' costs which all cost time money. This is why printed polymer technologies are promising. This is interesting both for putting on 'yoghurt' items and for integrating into packaging.

☞ What about the internet of things? ☞

Is RFID designed to remove people from the process? At this point there was discussion around real industry intentions, are they just removing checkout and warehouse workers. Is it about efficiency or removing people? The response from Fraunhofer was that perhaps we are removing some 'slave jobs': the jobs are being transferred into IT and integration work. Fraunhofer stated that they probably cannot be addressed at the institute, that the problems were too complex.

☞ What about embedding privacy at the hardware level? ☞

Rob Van Kranenburg is adamant that privacy can also be a unique selling point: look at the IBM clipped tag, customers and users are less critical once they have control over it. If privacy had been considered and integrated from the very beginning, then it would be now much easier to sell RFID. Very many people are critiquing RFID now, from science fiction to art, politics, activism. In the next three years privacy will be in the centre of international attention, and even technical RFID research should engage with this.

The response from Fraunhofer was non-committal about this, it seems as if they had not fully considered the privacy issue at a hardware or software level. Overall they are not yet being dealing with at a technology level, instead focusing on fundamental hardware and software problems. This seemed like somewhat of an oversight, and it could be something that they factor into their research, at least at a high level.

Thanks to Susanne Ackers and Francis Hunger for the excellent realtime translation.

(June 12, 2006)

Editorial note: The above articles by Timo Arnall were first published at <http://www.nearfield.org> and reprinted with permission. (F.H.)

A STATEMENT ON THE RFID WORKSHOP IN DORTMUND

by Franziska Nori

Rfid is a rather elementary technology based on the principle of sender-receiver communication. Its emergence on the global markets has been taken place without causing any large visible public reaction. Largely employed in the domain of product logistics rfid tags start to permeate our daily life in a subtle and non-reversible manner. The alarming tendency we will have to face is the use of rfid in the context of personal observation and the interconnection to a series of diverse databases permitting an easy cross-linking of personal data and therefore surveillance. Also the miniaturisation of rfid chips and therefore the augmented pervasiveness (as for example envisioned by the military) will broaden the possibilities of strategic employs of this technology. Weather it might be governmental or commercial entities applying it the feasibility of extensive surveillance thanks to rfid tagging is a rather scary jet realistic scenario.

It is evident that there is a need for understanding and publicly debating possible consequences of the vast implementation of this technology and the impact it can provoke to our current society. It also seams clear that rfid technology, within itself neutral as all technological achievements are at first before getting hijacked in their purpose, also bears a high potential for culturally relevant creation worth to be explored.

The workshop in Dortmund was a great opportunity to join forces among experts from very different fields to discuss challenges and eventual risks related to this new reality. Thanks again to the organisational team of Hartware-MedienKunstVerein Dortmund!

(September 14, 2006)





PHOTOS



by Inke Arns







COPYRIGHT



The copyright of this publication remains with the writers and photographers.

the use of RFID in the context of the World Cup and sketch a future vision for the use of RFID compatible with privacy issues.

☞ 2:30 Rob van Kranenburg (Virtual Platform, NL) ☞
Rob van Kranenburg will speak about RFID and Pervasive Computing, i.e. how computer technology increasingly permeates our everyday life. He sees RFID as an unavoidable logistics technology that poses the question of social control.

☞ 3:30 Dipl.-Ing. Wolfgang Lammers (Fraunhofer Institut Materialfluss und Logistik, Dortmund) ☞
The Dortmund Fraunhofer Institute is one of the most significant research centers for RFID technology in Germany. An overview of its working areas and current research projects will be given.

☞ 4:30 Rasa Smite, Raitis Smits (RIXC, Center for New Media Culture, Riga) und Honor Harger, Adam Hyde (radioqualia, NZ/AUS/GB/NL) ☞
Honor Harger (radioqualia) and Rasa Smite (RIXC) speak a.o. about Solar Radio Station, an live installation which features sounds from the Sun.

☞ 7:00 – 9:00 Solar Radio Station – Live Installation ☞
The Riga based group Clausthome and VJ Martins Ratniks (F5/RIXC) will perform live in the Solar Radio Station. The live audio stream from the VIRAC radio telescope in Irbene, carrying data from the sun and from space, will be electronically enhanced by Clausthome and interpreted visually by VJ Martins Ratniks.



ACKNOWLEDGMENTS



My personal acknowledgments go to Susanne Ackers for inspiring the workshop and to the HMKV Team (Dr. Inke Arns, Dr. Susanne Ackers and Darija Simunovic) and Dr. Kurt Wettengl of Museum am Ostwall Dortmund, who made the workshop possible. Additionally I would like to thank Rena Tangens, Padeluun and Wolfgang Prüßner for developing the hands-on part of the workshop and also the lecturers Bruce Sterling, Rena Tangens and Padeluun, Wolfgang Lammers, Rob van Kranenburg.

With great interest the participants followed a guided tour and the discussions at Fraunhofer Institute for Material Flow and Logistics, Dortmund by Monika Nemeth and Ralf Neuhaus – thank you very much for creating the possibility. I would like to thank the participants and especially the spontaneous participants of the workshop who created an atmosphere of exchange, critical discussion and developing ideas. I'm grateful to the authors of this small publication who added their points of view.

Francis Hunger



PUBLIC LECTURES



☞ 10:00 Welcome and Introduction ☞
Screening of the video „The Catalogue“ (GB 2004, 5:42 min.) by Chris Oakley, Welcome: Dr. Inke Arns (Hardware MedienKunstVerein, Dortmund), Rasa Smite (RIXC, Center for New Media Culture, Riga), Francis Hunger (Hardware MedienKunstVerein, Dortmund)

☞ 11:00 Keynote: Bruce Sterling (Autor, Belgrade) ☞
Bruce Sterling is a science fiction writer who has, among others, shaped the notion of „cyberspace“ together with William Gibson („Neuromancer“). In his blog <http://blog.wired.com/sterling/> he discusses future technological developments.

☞ 12:00 Rena Tangens, padeluun (FoeBuD, Bielefeld) ☞
Rena Tangens and padeluun are the most articulate and outspoken critics of RFID technology in Germany. They will speak about their Stop-RFID campaign, the Metro scandal,



SUPPORT



Kulturbüro Stadt Dortmund, 38. internationale kulturtage der stadt dortmund / scene: estland lettland litauen in nrw Kunststiftung NRW, Der Ministerpräsident des Landes Nordrhein-Westfalen, Kultusministerium der Republik Lettland, Lietuvos Institutas, dortmund-project, LEG, PHOENIX

– In the frame of „face the unexpected. media art from estonia, latvia and lithuania“ at Museum am Ostwall and PHOENIX Halle Dortmund –



CONCEPT & REALISATION



Francis Hunger (HMKV Dortmund)
<http://www.hmkv.de>, <http://www.irmiellin.org>

☞ in cooperation with ☞
Rasa Smite and Raitis Smits (RIXC, Riga)
<http://www.rixc.lv>