Internet of 'Mysterious' Things

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Abstract. This fictional story uses technological advances in the fields of sensor technology, personal area network communications, and ambient assisted living, to explore the possibilities for future assisted health and wellbeing. It occurs in three time frames: past, present and slightly into the future (Sept 2011). Most of the hardware mentioned in the story is working, either in everyday life or is under development by companies for specialist sports and leisure applications. However the sensor to predict acute myocardial infarction is speculative and may be seen as the 'holy grail' of sensors, facilitating prediction of adverse events, and allowing preemptive treatment. Communication within the personal area network and to/from the Internet, realizes the concept of an "Internet of Things". As always the software struggles to catch up with the hardware, in order to provide a usable and reliable system. The software is depicted as a set of communicating intelligent agents, under the control of a dubious 'virtual' coach, and this introduces uncertainty and mystery. The story unwinds during the Berlin marathon 2011, a fitting setting to test whether stress can be assessed using ambulatory technology. Hans Fallada's novel, "Alone in Berlin" set in the 1940's and David Bowie's Berlin trilogy of alternative music recordings, produced in the late 70's, provide ominous and foreboding backdrops to the story.

Keywords. Internet of Things, sensor technology, motivational feedback, intelligent agents, Berlin marathon, Hans Fallada, Bowie, ageing population.

Introduction

The 'Internet of Things' provides a vision of connected artifacts, possibly working autonomously. This essentially puts 'Things' into communication, on a similar level to people communicating on the Internet. As the 'Things' may be provided with in-built intelligence in the form of software agents, could this have unintended consequences? Many science fiction stories have already testified to a nightmare vision of the future world in which things (robots) rebel and spiral out of control, dictating to humans. What will happen when the 'Things' have more influence over our lives, particularly when vulnerable, and in need of assistive technology?

This prototype story points out the potential advances but the science fiction element builds on these fears. If the controlling software agents are dysfunctional, erroneous, not properly tested or verified, or perhaps endowed with an 'evil' attribute, then unpredictable 'mysterious' things can happen. The prototype depicts technology to support a 'fifty something' runner (the author) during a marathon in Berlin, set in

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September 2011. The story is a confluence of the advances in sensors and wearable technology interwoven with reflections of the novel – 'Alone in Berlin', by Hans Fallada [1]. The novel introduces two opposing characters, Otto a German citizen who becomes disenchanted by the futility of war after his son is killed and his interrogator, Gestapo inspector Escherich. David Bowie, the famous recording artist, lived in Berlin in the late 70's, having left the Unites States to battle drug addiction. He produced three seminal works, known as the 'Berlin trilogy', Low (1977), Heroes (1977) and Lodger (1979), which provide a music soundtrack, delivered by today's most pervasive technology – the iPod.

As the body dehydrates on a warm day mysterious things can happen to the mind and infuse a runner with self-doubt, and it is unclear whether the mysterious happenings are due to rogue software or hallucinations, due to the vivid setting, recollections of the novel and pure exhaustion. One certainty we should appreciate is that complex technical systems will always fail. In the circumstances depicted in this story, this ironically provides the safety net, and saves the day!

A backdrop to the story is the 'ageing society'. As we anticipate decades when people will live beyond 100, health and wellbeing should be promoted. Many have got the message, out pounding the streets or tackling complex exercise machines in gyms; others are less visible, tucked up in front of the latest reality TV show. For both groups expect the 'Internet of Things' to deliver, for good and bad!

1. Published Work

The story brings together research undertaken by members of the Smart Environments Research Group, Artificial Intelligence and Applications Research Group, their PhD students and colleagues at the University of Ulster.

The Ambient Assisted Living (AAL) paradigm requires advances in sensor technology (*CIPS: Centre for Intelligent Point of Care Sensors*), the deployment of this technology in garments (*Design For Ageing Well: Improving the Quality of Life for the Ageing Population Using a Technology Enabled Garment System*) and in the environment (*RCIF: Deployment of Sensing Technology in Connected Healthcare;*); and the feedback of information on appropriate devices (*SMART2: Self Management supported by Assistive, Rehabilitation and Telecare Technologies*). This research is multidisciplinary and involves interaction with other researchers (designers, healthcare professionals, human computer interface experts etc.) and end-users. The theme of the story is the use of pervasive technology to facilitate wellness, as discussed in [2]. This requires pervasive, mobile technology, which is becoming available in applications such as NikePlus / iPod, and Global Positioning System (GPS) enabled artifacts from companies such as Garmin.

In [3], we report on the use of technology for self-management of chronic disease. Although this story relates specifically to a runner, this healthcare domain is where the technology could have most benefit in the future. One of the conditions we are investigating for self-management is 'chronic pain', and [4] investigates the use of decision support to assist end users, using home based and mobile technology. This in turn requires knowledge capture, often using machine learning [5]. As part of the decision support process we investigate the use of accelerometers for activity measurement [6] and posture recognition [7]. For this approach, 'end goals' are specified. These should be motivational; achieving the completion of a marathon is the

end goal in the story. Little attention so far has been paid to the possibility that feedback could be de-motivational and hence detrimental.

Comprehensive validation of technology is a key element; one alluded to in the story and often ignored, and [8] provides a cross-disciplinary study (with Health Science colleagues) to validate the step count activity data acquired from a mobile phone. Ambient Intelligence (AI), facilitated by the interaction of Intelligent Agents is key to the story. A review of the main AI concepts is provided in [9]. [10] investigates placement of electrocardiogram (ECG) electrodes in a 'smart shirt', allowing us to tap into vital signs, which could facilitate the detection of coronary dysfunction. The 'Internet of Things', as appropriate to health and wellbeing, was discussed in [11]. This story introduces the 'mystery' into the 'Internet of Mysterious Things'.

2. The Story, The Past (1981-2009): Technology Advances Rapidly

[Bowie] "In the event that this fantastic voyage should turn to erosion and we never get old".
{Friends} "A marathon at your age! Why?". I had been asked this question a few times already. My friends were curious why a 'fifty something' wanted to complete a marathon. I knew the answer. It made sense to me but it was hard to explain to 'baby boomers', now into their middle age, who didn't understand the running mentality, people who didn't understand technology, people who didn't understand that we are on the brink of another societal revolution, a silent revolution that could empower people, but also one that could threaten us all. The revolution is: "The Internet of Things".

I had been a runner in my postgraduate days in the early eighties. I was enthusiastic but always stayed at the 'fun' side. In those days, it was my approach to social networking; you actually met people! Running kept me fit but it also provided some clarity of thought, in the search for a 'contribution to knowledge' in the 'Speech Research Group' at Queen's. On training runs there was ample time to converse with fellow postgrads, time to think and be creative. We often used quotes from literature to goad, impress and inspire, mostly forgotten now or hidden deep within memory. My specialty was Shakespeare's 'Macbeth'. As the training runs became longer the thinking sometimes bordered on hallucination, as the body hurt and the mind rebelled. Our postgrad running group completed the first Belfast marathon in 1981 – our end goal achieved. Each member had their individual completion time, each a personal best (PB in running parlance), of course. My PB was 3:30 and 15 seconds. I resented those 15 seconds, and hoped for another try. So then what? Well nothing! Like an ill-conceived military campaign, there was no post-marathon strategy. We finished our research, and our network split. I needed the companionship and support – I couldn't do it alone!

Something curious happened in 2009. I bought a new pair of Nike trainers and decided to take up running again. I was motivated by the 'health and wellness' research we had embarked upon in the Smart Environments Research Group. However, these trainers were special – they were 'enabled'. They had a piezoelectric transducer embedded in the sole. This sensor counted steps. In itself, this was not new; pedometers were in widespread use by the masses, used to encourage exercise and tackle the 'diabesity' crisis brought upon us by the affluence and over-indulgence of the intervening years. But there was a subtle paradigm shift; these shoes could 'talk' to my Apple iPod music player, a personal area network that had made it 'out of the lab'.

Technology had advanced to such an extent that whilst listening to songs from my complete record collection, time and pace information, could be spoken to me by my new 'imaginary friend', who I'd named Belle. I had chosen a sympathetic American female voice from the deep south, – in reality of course I knew it was just a good speech synthesizer, which probably owed much to the research initiated in Bell Labs in the 1980's, and furthered by a number of groups including our own. However, I again had companionship during my runs. Belle also provided me with much need 'back bone' for the hard times on the road - my very own Lady Macbeth. Better still my training data could be uploaded to the Internet, and I now had a host of 'virtual' training companions and a coach, who set me tasks – usually quite unachievable. My social network was back! I didn't care that the companions were in different countries, in different time zones, or that the coach was really a software agent. It provided the motivation. I was no longer running alone.

2.1. Ich bin ein Berliner ("I am a Berliner", John F. Kennedy)

{Friends} "Why Berlin?". Again, I had an answer. Motivation was everything. I wanted to run a marathon again – perhaps to beat that 3:30 mark - I needed an end goal! Belfast was a tough, hilly course and could be cold. Berlin was flat and interesting. Why run a marathon in Belfast when I could run finish under the historic Brandenburg Gate?

And then there was the novel by Hans Fallada – 'Alone in Berlin'. *In the story, set in war torn Europe in 1940, Otto, an ordinary German living in a shabby apartment block, discovered his only son has been killed fighting at the front. He was shocked into an act of futile resistance, and dropped anonymous postcards, attacking Hitler, across the city. Otto was proud and stubborn. His adversary was Gestapo inspector Escherich. The novel depicts a 'cat and mouse' search for the card dropper. As Otto's family and associates are disposed of, the story culminates in an intense interrogation of Otto by Escherich.* Fallada portrayed such an atmospheric picture of 1940's Berlin that I wanted to experience the locations mentioned. How better, than weaving my way past them – this would be the motivation. Running the Berlin marathon would be *my futile act* of defiance to my advancing years, it would show the 'baby boomers', it would achieve noting, perfect!

And then there was the music. Bowie's brilliant late 70's Berlin trilogy of 'Low', 'Heroes' and 'Lodger', bleak, but nonetheless compelling. These were the vinyl days, the soundtrack to my PhD. This was a time when the world was a much bigger place, when IBM and DEC ruled Information Technology (if the term even existed!) and Ken Olsen (co-founder of DEC) couldn't envisage that anyone would ever have the need for a personal computer. In reality, I couldn't blame Mr. Olsen for his lack of foresight. Who could ever have predicted the consequences of such a digital revolution? Who would have thought that my large vinyl collection would now fit into a device the size of a credit card, and that I could listen to any song as I ran along a street in Belfast?

And then there was Belfast in the early 80's. Like Berlin, it was divided in places by a wall, a barrier between feuding communities. The wall in Berlin was breeched in 1989, but still the 'peace-line' exists; porous and selective but still necessary. In software terms, Belfast's wall was a 'bottom-up' design, needed to separate local communities; Berlin was 'top-down', testimony to an outdated political system. In my mind Belfast and Berlin were linked. It had to be the Berlin marathon!

3. The Present (March 2011): The Internet of Things

In the subsequent technology race of the last 30 years we have witnessed the personal computer, the Internet, the World Wide Web, the mobile phone network, the smart phone, the mobile Internet and the social network. All are interwoven into society – and in true Darwinian fashion the dinosaurs have fallen, and the visionaries remain. These technologies have radically changed our lives and led to the Information Society. In the next 10 to 15 years, the 'Internet of Things' will provide further disruptive change to society. *"The Internet of Things links the objects of the real world with the virtual world, thus enabling anytime, anyplace connectivity for anything and not only for anyone."* [13]. Success in achieving this relies on advances in sensor technology, tracking technologies, low power communication protocols, information and communication technology and cognitive science.

Inevitably, there will be ethical dilemmas, particularly with regard to the emergence of a surveillance society, which could easily spin out of control, as intelligent devices become more autonomous, taking their own decisions. In science fiction artificially intelligent systems often become self-aware, revolt against their creators and in some cases the boundaries between 'human' and 'artifact' are blurred.

3.1. A Personal Area Network

The running was going quite well. I had completed two half-marathons and it was 'all systems go' for Berlin. I had been 'technology enabled' on these runs, collecting information on GPS, elevation, heart rate, steps and pace. I was able to analyze these data after the runs, so that I could conceive relevant feedback, which would assist in my run – decision support; when to speed up, when to conserve.

If this technology worked well and crucially if it could be easily used, it could be transferred to the 'active ageing' and possibly those with chronic disease, to provide unobtrusive monitoring and motivational feedback. It could provide information on activity levels, and whether a person was reaching their goals. It could interpret danger signs, such as elevated heart rate, or possibly a fall. The technology could also be used to detect if the person was 'wandering', a more obtrusive, possibly unwanted side effect. I reconciled that the ethical debate was for another time/another place; we needed the technology.

Running was not my only motivation. I conceived a new experiment. I knew I would be stressed during a full 42Km marathon – this would be needed to test the 'new' device. It was the perfect opportunity, and I could by-pass stringent ethical procedures. I was the only subject, alone in Berlin – no one else would know.

3.2. A Multi-agent System

Our research into wearable computing was gathering pace and we had developed a new 'smart shirt'. This comprised sensors, which used the 'Shimmer' platform to pick up body temperature, respiration and ECG and transferred the data to an Android based smart phone. The phone had a 3G connection, so the data could also be uploaded to a web portal 'during' the training run, assuming an 'always-on' connection. This was to be a truly responsive pervasive system, with feedback being provided on-demand by the decision support system, located at the portal. The decision support was experimental but crucial to this advance. It consisted of a number of intelligent agents,

which interacted to produce sensible advice. This was a realization of the 'Internet of Things'.

The coach was in overall control. It received information from all the other agents, and used this to provide specific advice and an overall recommendation on continued effort; *speed up or conserve energy, take on fluids*? This was complex software. Each agent had embedded code and communication facilities, so that it could converse with the coach. The *Pace Agent* used the Nike piezoelectric transducer, but not just to communicate with the iPod. The data was forwarded to the portal, using the phone's 3G connection. The *Heart Rate Agent* used an algorithm for QRS detection. This provided heart rate, but also allowed variability and more subtle measures such as ST elevation to be computed. For the present only heart rate was used but the potential was enormous. For example we could compare variability with stress measured from sweat to investigate electrical correlates of stress levels – all 'in the wild'.

The *Breathing Agent* used changes of the electrical resistance of fibres woven into the running shirt to measure the rate and depth of breathing. This was a robust and transparent metric for any runner – no disguising breathing, when the going gets tough! The *GPS Agent* was built into the phone. This measured distance covered and verified this against the step counter in the Pace Agent. But it could do more; it could measure elevation, and hence provide 'context' for changes in pace for the Context Agent. The *Body Temperature Agent* measured peripheral body temperature. As the body heated up and dehydrated, feedback could advise the runner to take on more fluids, crucial over long distances. Cold temperature could also indicate a quick decline in physiology, so the Body Temperature Agent worked before, during and after any run to oversee wellbeing. In reality researchers much prefer to measure 'core' body temperature, but there are some things an end user must draw the line at!

The *Context Agent* had a difficult job. It has to take information from the agents and provide a summary to the coach. It could even take into account the weather forecast from the phone's weather web service. It used decision support rules to provide a recommendation. *The runner is moving quickly up a steep incline. This explains the elevated heart rate.* The coach could decide to use or disregard this information. The *Feedback Agent* was my friend Belle. Her voice resided on the iPod; she[2] was really quite dumb, she could only do what she was told. However, being part of the body area network provided closeness and fault-tolerant operation. She travelled with me.

The coach was the Boss. Given a 'goal', e.g. complete the marathon in 3:30, this agent could work out whether the current pace was acceptable given the course layout, using complex formulae and rules. The coach was always silent, unlike Belle. It issued longer term advice (actually 'dictats') in the form of comments on the Internet Portal. *Increase the frequency of your training runs. Post a better time for 10Km. Why haven't you progressed as quickly as other runners in your network?* It was only a recent software development linking the coach with Belle that provided the possibility of interactive feedback. This provided Belle with much more to do, during a run, reporting on all aspects, as the coach's puppet. The coach's feedback was motivational but always stricter by comparison with Belle. Still it was for the good, wasn't it?

[2] Note that Belle is intentionally provided with a human attribute ('she'). Other agents are things, but the coach takes on a human persona as boundaries between humans and things become blurred.

4. The Future: A New Device in a New Town

My colleagues in Bioengineering had been working hard on a new 'Point of Care' device - a myoglobin biosensing array. This could be used to sense raised stress levels from sweat on the skin, but it also drew a small sample of blood, similar to the insulin sensor used by diabetics. The device was administered to the upper arm, embedded in a plaster. I was told that the subject noticed a small 'jab', but it really wasn't painful. This did however pose ethical issues for testing – lots of unnecessary paperwork, I thought! This new sensor provided really accurate, almost 'real-time' indications of stress, and was a major technological advance. An in-built Bluetooth module provided a communications link to a phone. Preliminary research was pointing to the fact that subtle markers could be detected for enhanced risk of Acute Myocardial Infarction (AMI), prior to any heart attack. Drugs could alleviate the condition, if administered in time. This could be the body's very own tsunami early warning system – the 'holy grail' of sensors!

A prototype had been developed and wireless communication had been established with the phone. I had programmed a personalized agent for decision support – the *Stress Agent*. This would be the 'killer app' for healthcare. This would inform of raised stress levels and keep me to within sensible limits for my age, weight, heart rate etc. If the value was abnormal, the *Stress Agent* automatically did a retest after 30 seconds for verification. If this happened repeatedly it was not a good sign. The device worked, I was assured, but the integration had never been tested, so far. In fact, it couldn't be tested until we had gone through ethical, governance and regulatory hoops.

4.1. Alone in Berlin 2011 – 25th September 2011

Marathon day arrived. It was 27 degrees Celsius and mercifully cloudy, but still not weather conditions that runners really want. The weather forecast predicted a hot afternoon. However, the marathon itself was 'uber' cool and hence attracted the masses. I had entered via the Internet, of course, in Sept 2010, and obtained 1 of the limited 40,000 places. A simple health check questionnaire had to be completed. I answered the questions and forecast a time of 3:45. This would be pretty good for my age, and would not produce any alerts. I was in!

On the morning, I met with members of my 'virtual' social network, and discussed race strategy. They had come from Germany of course but also Spain, France and USA. All anonymous pseudonyms until now. Everyone agreed that in a marathon you shouldn't start too fast, you should take on plenty of fluids, especially in the heat. We agreed to meet for a beer at the finish. From then, I was on my own in Berlin.

I donned the smart shirt which monitored breathing, temperature and ECG, attached the new stress sensor plaster to my arm. I wore my usual running shoes complete with pace sensor, linked this to the iPod and checked for connectivity to my phone. All the signals were communicating. I put on my race number with official race chip for timing. The start was in 'Strabe des 17. Jui', a wide thoroughfare, in the centre of the 'Tier-garden', close to the 'Grober-Stern' monument. I started more than halfway down the field, where I wanted to be. I wondered who was at the front, possibly the great Haile Gebreselassie; certainly high class African runners. They would run the course in under 2:10. Someday 2 hours would be broken, as significant a barrier as the '4 minute mile' in the 60s. Maybe pervasive technology would facilitate

this, in the near future. Was Paula Radcliffe running in the ladies race this year? Still world record holder. I was rooting for the 'oldies'.

Although I was in a heaving crowd, I was quite alone – just for the next 3:30! My mind threw up a quote from yesteryear. *"If it were done when 'tis done, then 'twere well it were done quickly."* There, I was doing what I had advised against, going for a PB already– subconsciously. But I had embedded technology looking after me, nothing could go wrong! As the start time approached, the level of excitement and anticipation rose. I started to monitor my data. I could feel my heart racing, breathing was heavy, and I was sweating. The sweat was required, needed for a good connection for the ECG electrodes. I awaited the starting pistol. I started the Bowie soundtrack on my iPod. *[Bowie] "And the guns, shot above our heads."*

My first feedback from Belle: "*Breathing level fast and elevated heart rate, please slow down*". I hadn't started yet! Surely the *Context Agent* should have known. An Error! Then "*Body Temperature is 37.5 Celsius*". Too warm, already! In fact, for the next 15 minutes, all I could do was walk, as the swarm of runners transitioned from stationary, to fast walk, to canter. I finally made it past the start. I pressed the start time button on my GPS enabled watch. My race chip, supplied by the organizers, clicked into operation so that I could obtain an official time. However, I couldn't link it to my network, an unknown communication protocol. Interoperability issues, as always. But I was under way, only 42Km left. I started fast!

The course headed west, then turned right before doubling back, past the impressive, historic Reichstag parliament building. The sun peaked through the clouds and caught the dome, sending a blinding glare to the ground. I could see the victory arch of the Brandenburg Gate on my right, but I wouldn't pass under it until the end, if I made it. The first 10Km was easy. I was distracted by the runners, the supportive crowd and the environment. I had made the correct marathon choice – definitely! I was exceeding my expected finish time of 3:45, surely I could do 3:30 in Berlin. Belle gave me positive feedback every Km. However, she relayed decision support's recommendation to 'slow down'. If I didn't, I would pay for it later. I ignored her!

4.2. Sense of Doubt

Now, I was in the East, the 'Mitte' district. The sun had finally won its battle and risen overhead. It was the heat of the day. The race began to take its toll. I needed to keep my mind occupied. I began to think about Otto. He lived in one of these apartments. Why start distributing anti-war postcards – surely nothing was achieved by it, pure futility? I contemplated the cheering crowd and thought about 'party spies' in every apartment block in the 1940s. Fear and suspicion had been replaced by exuberance and support. How much society had changed in those years. I hoped that the 'Internet of Things' would not take us back to surveillance and mistrust, but feared that it would.

Then something mysterious happened. My 11Km feedback report was not from Belle, but from a man's voice, in English curiously but with a defined authoritarian German accent. Some strange error had occurred. Must be a software glitch – these errors were a feature of every program I had worked on for the past 30 years – always bugs. Maybe the GPS has somehow localized the iPod to Germany, and I had lost Belle. Unlikely, I thought, but plausible, given the complexity of the software and communication protocols. Ouch! I felt a jab in my upper arm. Not altogether painless. I must be getting stressed. Now was the time to dig in, and pretend (to myself) that it was easy.

4.3. Agent Provocateur

However, in the background, on the portal, ominous things were happening. The coach had negotiated initial transfer parameters autonomously with all the other agents. This was good software engineering practice. It promoted cohesion and generalization. As the coach's software agent was in control, it monitored their values, but after 10Km as we entered the East it executed an over-ride. Belle's feedback agent was ordered to stand down. The coach would provide the feedback directly over the 3G connection.

At 12Km, my pace was still good, heart rate elevated but as expected, temperature just above normal, no further indication of stress. I took on water for the first time. This would be a rich data set, I was sure of it. Time to think of other things, anything but running. South to 'Neukölln', the eighth borough of Berlin, and the foreboding sound of the instrumental from 'Heroes', then west to Schoneberg. All the time the music kept me going, pounding out Bowie's bleak rhythms of 70's Berlin. More thoughts of Otto and his tussle with arch interrogator Inspector Escherich. Why didn't Otto give in? He was my inspiration, if he could resist then I could too! 15Km became 18Km. The markers went by, more in a blur now, the crowd thinning, muted and less relevant.

Then at 20Km, the mysterious German agent's feedback, once again. I was sure it was the coach. This time, bad news for me; my pace had fallen (both NikePlus and GPS apparently agreed), decision support informed that I must increase the pace. I responded and quickened. At 22Km, similar feedback; my effort was in vain. Then another jab in my arm, followed 30 seconds later by another. I was told this was painless – it wasn't, a mental note for the ethics form! I sought feedback from the *Heart Rate Agent*: 'normal'. Surely not, I could feel it pounding in union with my stride, bursting in my chest. Then the *Breathing Agent*: 'normal'. I knew it wasn't. Then the *Body Temperature Agent*: 'normal'. Why did I feel so hot? I reckoned that the *Context Agent* must have malfunctioned, but it did a self-test and reported 'normal'. So only the *Feedback Agent* broken? Finally the *Stress Agent*: 'normal'. The coach demanded more – no time for water. Another jab, and another. This was ominous, I was being tested. I looked for spies in the crowd.

My thoughts turned to Escherich. My mind overactive as my body toiled. This is the district where Otto was finally caught and subsequently interrogated; I'm at my most vulnerable, now. Feedback again, the German accent, was this Escherich? Had he done away with Belle, as he had done with Otto's friends. Was he not only my coach but my interrogator? My heart rate was high but it was reported 'normal'. I was hot but temperature was reported 'normal'. My breathing was high but it was reported 'normal'. Had Escherich got to all the other agents? Why was I being fed mis-information? I knew one thing, like Otto, I mustn't give in. I must keep going. My quest was not futile.

4.4. Hitting an all time Low

I kept going for the next 10Km. I knew I was putting in more effort, but the feedback was not motivating. It was demoralizing. I knew I was stressed, but the *Stress Agent* reported 'normal'. My legs were leaden, my body ached, my mind said surrender, do it now! My coach said, "faster". Upper arm jabs were more frequent and more painful. A trickle of blood came down my arm onto my hand. "Out, damned spot! out, I say!"

My arms dropped – always a bad sign. I lifted them again, lest they betrayed me to the other runners, all spies now! It was 32Km, still 10Km to go. I needed to hear from

coach Escherich, even though he was my tormentor – I needed the feedback. My coach said "faster – no time for water". I'd started too fast – I knew it. I looked around. Everyone around looked to be in better shape. They were overtaking me. Should I give up? My thoughts were now clouded, even Bowie's soundtrack goaded me. *[Bowie] "Get me to the doctor, get me off the streets (get some protection). Get me on my feet (get some direction)"*. Had he turned against me, too? This was my interrogation – I was sure. Is Escherich trying to hide the *Stress Agent* from me? Is he playing with my mind? Is he trying to induce AMI? Did he want me to surrender before I tested the ill-named 'killer app'?

Then it hit me! He was using reverse psychology, goading me – he knew I would keep going, just like Otto. That would be my demise. I'd rumbled him now. If I could ignore him and all the technology I could coast home. Otto had got the better of Escherich, by defiance. He was my inspiration. I would do the same, by disregarding his advice. I banished Escherich from my thoughts. Don't think of the pain! I needed a distraction to get me through this. He was gone. *[Bowie] "Sons of the silent age listen to tracks by Sam Therapy and King Dice"*.

4.5. Saved by the Belle

I lifted my arms and looked up. I was passing the Zoo station. My thoughts went back to '*Christiane F. - Wir Kinder vom Bahnhof Zoo*'. In the 1981 film Christiane, a 14 year old, lived with her mother and little sister in a multi-storey apartment building in Berlin, just like Otto. She met a boyfriend at a Zoo station disco, and step by step she got drawn into the heroin scene. It was a different era and another bleak backdrop to Berlin. It was a film, I knew well, as it used a Bowie soundtrack.

I used it as a distraction. I went through the scenes in my mind. This passed a few more Kilometers. The jabs in my arms, the delirium, just like an addict from the film. Was I doing my 'cold turkey' now? Turning east again, time for water - at last, at the 'Kaiser-Wihelm Gedachtnis-Kiche', a monument to the futility of destruction, left desolate as a gesture, just like Otto's postcards. Maybe these gestures are not in vain, maybe they are a reminder to us all. I must be positive, regain hope for the future. Only 6Km to go. Feedback, but this time from Belle. I'd survived. I'd seen off Escherich. This was my metaphorical last lap.

On the portal the multi-agent system has suffered a fatal unanticipated error. The 3G connection was overloaded and hence broken, due to the volume of calls from early finishers. Escherich could do no more, so Belle and the personal area network took over. Normal service was resumed.

I arrived at Checkpoint Charlie, a gateway to freedom, in post-war divided Berlin. Could I get through? I had all the credentials – I had been tested but had survived. One last effort to get to my goal. 5Km to go, now. I knew I could make it. I was positive. I checked on my predicted time from Belle; 3 hours 31 mins. I accelerated down 'Postdamer Strabe'. I was passing 'Das Hansa Tonstudio', where Bowie recorded 'Low', 'Heroes' and 'Lodger', no time to wander by now. The water had done the trick, I was thinking clearly again. I had just come through the fabled marathon 'wall', *[Bowie]* "*Standing by the Wall*". Was Escherich an illusion? "A dagger of the mind, a false creation, proceeding for the heat oppressed brain"

Now I was passing runners, in the ascendancy. Belle was optimistic. I could achieve my end goal. 2Km to go, still a possible PB. What an incentive. Into 'Unter den Linden'. Think of the beer at the finish, think of anything except pain. I can see the

famous Gate. At its top is the Quadriga, a chariot drawn by four horses driven by Victoria, the Roman goddess of victory. This was to be my victory. *[Bowie] "We can be heroes – just for one day!"*. I quicken pace. I pass under the arch and my race chip records my time.

30 minutes later. Still didn't know my official race time, but it would be close. My watch stopped at 3:30:45 seconds (30 more years and 30 more seconds), but the race time could have been faster. I would have to wait a few days for confirmation. I hoped that Haile and Paula were victorious – one for the veterans, each "a poor player, that struts and frets his hour upon the stage, and then is heard no more". I checked the phone for a portal connection: '*Error: Connection unavailable*'. I wondered if the data had been stored on the portal. Was my run in vain? Had I obtained any stress data from the new sensor? I doubted it, the file needed to be closed – as always human error, and the experiment fails.

Now some time to ponder - more questions than answers. Had my coach become 'self aware' and plotted against me or had I simply hit the wall? I examined AMI device plaster, definite jabs, but no blood. It must have been the latter. I must have been stressed. I should have started slower and taken on more fluids – remember for again. Why did I do it alone? I needed a human to monitor that the experiment was going to plan, and close the file. So there is a need for ethics and regulation, after all – I mused. We do need a safety net, when the technology fails, as inevitably it will. But this was still victory for me. I had finished the race. I had paid homage to Bowie and Fallada. I had seen off my personal interrogator Escherich.

I was alone in Berlin except for Belle, and about 35,000 finishers. About 5,000 would lose their battle. Time for a Weissbier with the social network. "Did anyone start too fast, I enquired?". [*Runners -all*] "Ya", "Si", "Oui", "Yea". The 3G signal was back. The Body temperature agent reported normal. I phoned my friends to report my victory. *[Friends] "We always knew you could do it!"*. I could only have done it in Berlin.

5. Summary

The technology referred to in this story is under development. Some is already in widespread use (e.g. Nike plus and Apple iPod system). Smart shirts allow the recording of heart rate, and concurrent recording of GPS. Such technology has been used to allow television viewers to follow riders in the Tour De France, for example. The iPhone has apps, which combine GPS and step count. The 'Internet of Things' envisions a technology where components communicate autonomously. This has huge potential for health and wellness. There are many motivations for this prototype.

1. To extend the specialist technology for the masses; older users or people with chronic disease, who could benefit from ambient, unobtrusive assistive technology.
2. To promote easy integration of the various technologies on a common platform. Usability is a key issue. It's impossible for a runner to utilize these components. Integration is key, whether it is on an open platform or through an applet store.
3. The 'killer app' depends on progress on sensor design. If feedback could alert a user to the fact that stress levels were high, then interventions could be significant. This is the most speculative advance, and the one that may not occur.

4. Software agents should be used to control devices and feedback appropriate information based on decision support. Software necessarily lags hardware advances. However reliability of this software should be ensured.
5. Feedback in the self-management paradigm will not always be positive and motivating. Will the technology have unintended consequences?
6. To stimulate the ethical and research governance debate, for disruptive advances.
7. To remind that complex systems will always fail and we need a safety net!

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