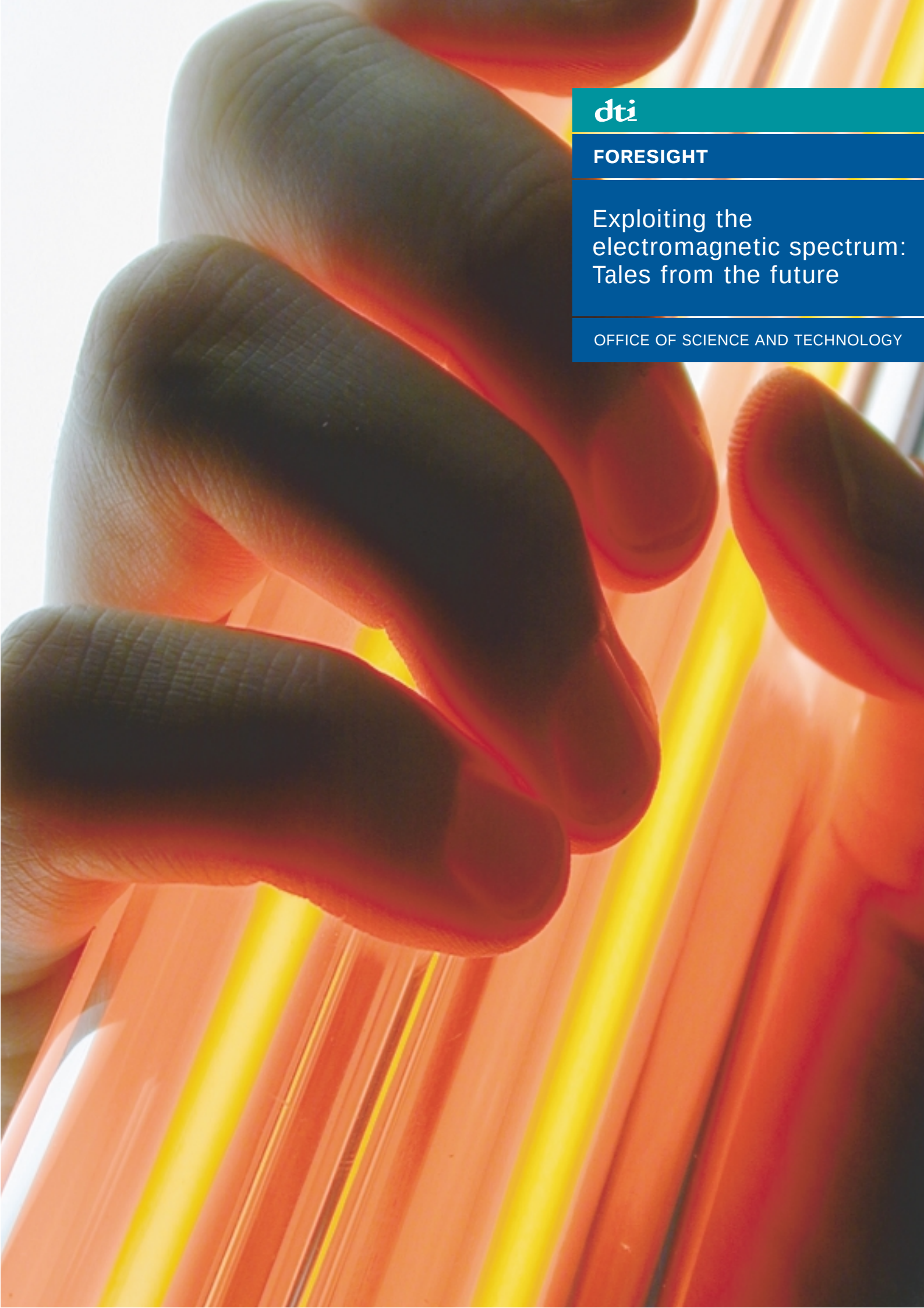

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FORESIGHT

Exploiting the electromagnetic spectrum: Tales from the future

OFFICE OF SCIENCE AND TECHNOLOGY

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Introduction

The Foresight project on 'Exploiting the electromagnetic spectrum' (EEMS) set out to provide a vision for the future exploitation of the electromagnetic spectrum to ensure increased UK innovation in selected areas. The project has investigated highly technical research in areas of physics not always easily accessible to non-experts.

These narrative stories were commissioned from Mosse Associates to explore and bring to life aspects of the technological developments identified by the project in a way that is accessible to all. In creating visions of the possible future, they also add another perspective to the conclusions of the project and provide an example of the use of narrative writing as a futures tool. The writers were given full artistic license so the stories do not necessarily reflect the views or opinions of the project and its action groups.

Mosse Associates is a partnership between the writer and broadcaster Kate Mosse and her husband Greg Mosse, author, translator, web writer and teacher. They have worked with Orange, the British Council and other arts and business organisations to use creative writing in a variety of novel ways, including a ground-breaking interactive website for which Greg is webmaster – www.orangelabyrinth.co.uk – based around Kate's forthcoming novel *Labyrinth*. Kate's previous novels include a biotech thriller called *Crucifix Lane*. She co-founded the Orange Prize for Fiction and was one of the judges for the 2003 Aventis Prize for books of popular science.

Connectedness becomes disconnectedness

The multiscreens in the lecture room were dark. From the technician's room directly below came sounds of voices, greetings. A scraping, as of a chair being dragged across the floor, was heard. Then, with a soft whirr of concealed cooling fans, the flat panels of the multiscreens flickered and came alive with the Remote University badge. First the ceiling, then, in groups of four or five at a time, the four walls.

A hatch in the floor was pushed up and over, landing with an incongruous crash on the rubber floor.

Shanoor Miah climbed the stiff stairs into the centre of the lecture room. He held the skirts of his teaching robes hitched up in his two fists and trod carefully. If he tripped, it would not be the first time and Nicola, the technician, would be sure to have activated the cam already. Just in case.

Shanoor shut the hatch. It closed much more smoothly than it opened. Shanoor pushed it patiently into place with the sole of his foot as the hydraulic hinges cushioned its fall.

Sure enough, the cam was active. As Shanoor turned to visually check all the screens were live, it followed his gaze, racing round a track at the junction of ceiling and wall. It was virtually silent.

The cam was a sprightly piece of technology, but inconvenient. It meant the Remote students always had a downward view of the lecturer. It would be better for the cam track to run round the room at eye-level. But this would mean disrupting the format of the multiscreens, something technicians and accountants were loath to countenance. Shanoor tried to compensate by keeping his chin high and suffered a stiff neck.

There were seven identical lecture rooms on this corridor, all of them accessed from the technician's rooms below. The only modification Shanoor had managed in his room was the removal of the lecturer's chair. Standing meant his eye-line was closer to the swinging cam and his lectures flowed better – 'like water over a dam!' – when he was on his feet.

Shanoor glanced at the device on his wrist.

'Technician,' he enunciated clearly.

A tiny string of red LEDs pulsed to indicate dialling. After just three seconds a larger green telltale showed connection.

'Can we go through the notes, please, Nicola,' Shanoor requested.

There was a pause. The green telltale remained alight but Shanoor heard nothing. There was a thumping on the hatch from the technician's room below. Shanoor cursed lightly under his breath.

'Activate earpiece,' he enunciated carefully.

'Well done, Mr Miah,' the technician chided in his earpiece.

Wherever Shanoor looked, now, one panel of the multiscreens was live with the opening card of his notes. A sensor suspended around his neck was detected by the technician's software. As Shanoor turned and moved about the lecture room, the image of his lecture notes moved to a panel right in front of his gaze.

On each wall there were six rows of panels. His title page – 'Connectedness becomes disconnectedness' – ran around the room in the third row of panels, eye level for a seated lecturer.

> 'Could I have the notes in row five, please, Nicola,' he asked sweetly. He did not say out loud: 'As damn usual!'
>
> 'Two minutes, Mr Miah. Shall I enable two-way communication?'
>
> 'Just show them to me, please.'

In stuttering groups the multiscreens came to more vibrant life. Students perked up as their software told them they were connected to the lecture room. They composed their faces into earnest, worthy expressions of concentrated attention. Shanoor glanced about the room, making mental notes of some of the names, recognising a few, remembering older siblings of the fresher faces presented to him this fine morning. He did, after all, love to teach.

Before activating two-way communication, Shanoor glanced at the device on his wrist and said:

> 'Divert.'

He hadn't enunciated clearly enough. The wrist phone dialled and, within seconds, Dave Probert was answering in his earpiece.

> 'I'm sorry, David,' Shanoor apologised. 'Voice-recognition problem.'

Dave hung up. Shanoor spoke clearly to the device.

> 'Divert!' An orange telltale indicated the wrist phone was active but silent.
>
> 'Two-way and send them card one, please, Nicola.'

Shanoor's wandering title panel instantly displayed card one of his lecture notes. It was an old screen grab, from a long-defunct website, circa 2004:

> *Warning!*
> *Your brain is on internet overload.*
> *It has been brought to our attention that you have been spending too much time on the internet.*
> *Please take a break and go outside or something.*

It was Shanoor's habit to begin each lecture with an authentic historical document from the days of unfettered internet access, a time when everything was available, anytime, anywhere.

Nicola inserted a countdown clock in the top left of Shanoor's panel. The seconds peeled away, then the automated attendance registration system scrolled rapidly through the Remote attendees, like a computer counting memory.

Shanoor began:

> 'It is a trait common to all societies at all times in human history to look back to a golden age. Many societies looked forward to an imagined future which might also provide the mythical utopia sociological ingenuity had struggled to achieve in the complex present. Of course, these imagined El Dorados in past and future were simplified, schematic worlds from which difficult choices and necessary compromise had been excised…'

As his introduction unscrolled across the bottom of his panel, Shanoor's gaze flicked from student to student. He saw them stilled by his voice, by the effort of concentrating on his swiftly delivered text. Then, as they became immersed in his narrative, one or two began to type notes and interjections.

The interjections were sent via the technician, who appeared in the top right of Shanoor's screen. Nicola was a good editor. Those interjections she thought interesting she displayed in her top right-hand corner frame for Shanoor to assess and, if he saw fit, pass on to the other students.

Remote but almost live, a good compromise for teacher and students. The first student question he displayed was, as usual, a simple request for the core text of his lecture.

> 'Why was it a golden age?'

Shanoor was coming to it anyway.

> 'In 2004, all…' Shanoor coughed and started again.
>
> 'In 2004, interconnected storage networks were growing massively, driven by the knowledge economy. Technology often solves old problems at the expense of creating new ones. Consider the internet. The innovations of email, list servers, chat rooms, web pages, database access around the world, around the clock, logged and indexed. Plus logs of the interactions of those accessing computers and other devices. In 2004, the year we are discussing, total data increase per annum was 2 exabytes.'

Nicola posted a definition in another panel of the screen and Shanoor authorised her to post it with a nod.

> *An exabyte is a large unit of computer data storage, two to the sixtieth power bytes. The prefix exa means one billion billion. So that's a billion gigabytes per year. Hard to imagine, then. Everyday, now.*
>
> 'There were increasing amounts of globally accessible data of increasing economic value. Over the following 10 years the existing telecom network technologies were able more or less to meet expanding demand. But from that point on, demand outstripped advances in telecom technology.'

Nicola posted another interjection:

> 'What problems did this cause?'

Shanoor liked clear and to-the-point queries, but he held it back.

> 'Digital data via dial-up modem and broadband was available at all times – not necessarily "always on", though that was a common sales pitch, but always available. More importantly, in this "golden age", it was the goal of almost every institution of note – aside from those for whom secrecy was stock in trade – to make proprietary content available at all times in all places. Galleries posted thumbnails of their collections. Dictionaries of technology or world languages were posted, translation engines, catalogues of texts, the texts themselves. Shops, markets for goods and services were opened… Simile, please?'

A student Shanoor recognised from last term's course – *The Demise of Copper* – was already typing and posting:

> 'Like a library. You go in and ask for data on, say, flower arranging. The genius librarian knows the contents of every book in the library and takes you directly to an appropriate page. On the other hand…'

Shanoor pointed the device suspended around his neck to the appropriate screen and Nicola posted the text to all attending Remote students.

> '… on the other hand, you enter a library and a traditional librarian tells you to first go to the hobbies and handicrafts shelves, then to section within section until you arrive at the index of a book then a page in that book.
>
> 'Thank you. It is a fundamental shift. In 2004, perhaps a golden age, users could address the "genius librarian" – in our friend's felicitous phrase – directly. A real-time search was made of every page. The search technology was interesting. I refer you to…'

Nicola posted bibliographical details which the students captured dutifully. Then, in response to Shanoor's signal, she posted the query he had held back:

> 'What problems did this cause?'
>
> 'Maintaining accessible storage became a drag on the planetary network,' Shanoor

resumed. 'If every item of data had to be a live datum, accessible anytime, anywhere, pathways for retrieval become mind-bendingly numerous and complex. Mind-bendingly complex even for electronic minds.'

Several of the students posted 'Ha-ha' to this pale witticism.

'Instead of maintaining those stacked-up exabytes of data in a state of ready retrieval, whole swathes of content – reference material, archives, logs – had to be edited out of the live, real-time network and placed in a different form of retrieval mode. Instead of trawling for data at random in a boundlessly fruitful ocean, many data reached a state of remoteness from the real-time network which meant that only if you knew they were there would you find them. Once you knew the location of the content you required, you could request it. Example?'

There was a rush from the students to respond and prove their attentiveness and abilities. A brief expression of distaste crossed Shanoor's features as he asked the question. Students were graded on their responses to 'unseen' queries from the lecturers at the Remote University. He wiped his hands on his academic robes. Some of the students would fail to respond quickly enough and would be sent demerits. But he was obliged to include at least three requests for 'unseen' opinions in each presentation.

He indicated to Nicola which post to take and she displayed the comments of a tiny student who could scarcely be seen behind her desk.

'Blogs were the first to be removed from the live on-line world. The blogging phenomenon was transformed into closed circuits of users who communicated to one another in a kind of private but permanent party conversation. These communications were peer-to-peer rather than open internet publishing.'

'Thank you. Yes, some content became more distant. Connectedness became disconnectedness. Where was the initial part-solution found?'

'Yes,' he confirmed, responding to several of the students' posts, 'optical. Optical systems offered the possibility of fulfilling transmission requirements that copper connections were not able to meet. This is how the evolution was perceived at the time.'

Nicola displayed a new card:

Key challenges
Fast (<10 nanoseconds) optical switch (between interconnects and for switching in/out of storage media. Niche applications also.)
Storage – local or distributed?
Tuneable sources required for grid computing
Integration
Protocols & standards.

The lecture continued with a response to another student query.

'How successful was the switch to all-optical communications?'

'The success of the optical switchover was a function of the preparedness of the infrastructure in particular geographical locations. Remember,' he wagged a finger, 'we are speaking of fixed physical links for data communication – not infrared, not 3G and so on. In Singapore optical fibre laying was integrated with other public works. In Paris, the state telecoms provider set up a small Paris neighbourhood as an experiment in optical technology and, almost by accident, created a physical downtown for their ISP and content industry. In London, England, by contrast, the 1980s saw almost every street in the capital dug to lay copper cable – yes, COPPER CABLE – for TV services, one of the greatest missed opportunities in the history of that great city…'

Shanoor juggled information and humour, teacher-centred learning and interaction with the Remote students. He touched on agile components, infrastructure costs, techniques for quantifying increases in bandwidth and data storage, regulatory issues including copyright and ownership.

The internet's sensitivity to overload and denial of service attacks excited many responses from his students, some of them linking Shanoor's technical overview to the threat of cyber terrorism. Arcane citations were passed on:

> *Scaleable flow control for multicast ABR service in ATM networks*
> *Real-time transport of MPEG video with a statistically-guaranteed loss ratio*
> *Statistical analysis of feedback-synchronisation signalling delay for multicast flow control*
> *Refined Design of Random Early Detection Gateways*
> *A Scaleable Flow Control Algorithm for Point to Multipoint Communications in High-Speed Integrated Networks*

The historical migration to integrated backbone networks for voice, data, and multimedia applications was discussed. Quality-of-service routing using bounded flooding was aired.

Finally, though, Shanoor returned to the student he recognised from *The Demise of Copper*. The boy had posted a query and, risking the wrath of his lecturer, reposted it. It was the e-equivalent of interrupting without putting up your hand.

Shanoor took the query anyway. It was where he had been leading them all along:

> 'Is this any different from today?'

> 'Go on,' Shanoor replied.

The boy's workstation was enabled to transmit voice and Nicola allowed this over the closed network within which they were working. He spoke in slightly slurred second-hand English, perhaps from central Europe:

> 'This lecture is closed. It cannot be experienced outside of the closed loop. The bandwidth for us to exchange these streams of data…' Shanoor saw him wave a vague hand. '… has been booked and registered for this purpose. Instead of a global conversation everyone can join in on, this is like the private exchanges of blogs that were so appropriately mentioned earlier…'

Shanoor felt like telling the boy not to be smarmy, but held himself back.

> 'The same is true of many other circuits of information exchange which were once open highways. Our optical networks are overloaded. Two exabytes per year has become two exabytes per month. Fragmentation has occurred. Connectedness has become disconnectedness.'

Then, echoing Shanoor's earlier question:

> 'What is the new partial solution?'

> 'A sum of parts, I suggest.' He paused. 'Each of us, smart students especially perhaps, is a member of many communities. But our brains can only cope with so many contacts. Of course that was as true in the Stone Age as it is today, but now your co-students are all over the world. I do not know whether you are the better for talking to kindred smart students everywhere – but you are certainly the better for all being able to listen to me!'

Shanoor saw one of the students in the top row of multiscreens glance at her personal communicator on her wrist. As usual, time had flown.

> 'So let me put to you a different future,' Shanoor resumed. 'Most assuredly, I do not know all of your names, past results and preferences. I seem to remember you only because a note appears above you when you start to talk and that note reminds me of these things.'

One of the students posted: ‘Smart tag’ but Shanoor ignored it.

> ‘Perhaps in the future we will not really know anyone, even our “friends”, but our electronic contact managers will!’
>
> ‘I assure you,’ came the thin voice of the student from *The Demise of Copper*, ‘that you will remember me!’
>
> ‘Time – or perhaps frequency – will tell,’ said Shanoor, and he closed the Remote University lecture.

Crystal Bond

Maïta put down her glass of sweet dessert wine and spoke with clarity and force:

> ‘The development of the manufacturing process is essential and needs to be carried out in parallel with the research. The focus should be on low-cost, high-volume methods. We must find and incentivise manufacturers…’
>
> ‘Funding should be sought from research and commercial sectors,’ Tom interjected.
>
> ‘We should DO the research,’ put in Philippe.
>
> They conversation came up short.
>
> ‘Do the research.’
>
> And who was to pay?
>
> Chicken and egg.

When, in a secondary school of 700 children, just three opt to take A-level physics, they are likely to be or to become close. It is a little like the famous saying on families and friends – you are at liberty to choose your mates but your relatives are yours by right, for better or worse.

So, in school, a small family of physicists was formed. The three of them managed, on a kind of random rota, to outperform one another in tests and exams, so there was always something to aim for. They had taken the precaution of choosing different other subjects, so they never became sick of one another’s society.

Then, when higher education beckoned, was it surprising that all three should find themselves at the same institution, with each nurturing a similar plan?

Philippe continued:

> ‘You think things are bad, that public money is hard to come by. Do you know how banks work?’

Maïta and Tom both had a fair idea of how banks work, but Philippe clearly had a particular message to impart, so they encouraged him with nods and grunts.

> ‘If you can prove you don’t need the money, the banks are happy to lend to you. If you do need it, they don’t like the risk.’
>
> ‘But we are offering a return…’ suggested Maïta.
>
> ‘They don’t look at the return, they look at security.’

For two years or so, they studied and were recognised throughout their institution as geeks. That meant nothing more than that they devoted the majority of their intellectual energy to their subject, rather than focusing the greater part of their will on avoiding it. Each had pastimes outside of their curriculum, including rock climbing, speculative mathematics, a recorder consort, pulp fiction and, in one case, correspondence with his vast family.

As the opportunities of the science became

more real, however, with the increase in their expertise and a narrowing of focus on a particular shared area of interest, these hobbies began to fall away. The recorder consort replaced Philippe with a more reliable attender. Tom wrote less frequently to his relatives in Lincolnshire, who slackened in their assiduity, too. Maïta slowed the rhythm of her book-buying and took 300 paperback novels to the charity shop.

From geeks they became young fogies, serious-minded, slipping seamlessly into postgraduate research and their paths, for a little while, diverged.

> ‘But they must do business. If you are a publisher, you have to buy books from authors or you don’t have anything to publish. You have to speculate. Banks have to lend.’
>
> ‘But they lend to people and places where there is already money. That’s what I’m trying to tell you. They like to their money to rub up against other people’s money. They have found that some of it rubs off and they walk away from the party with more than they walked in with.’
>
> ‘Are you losing faith, Philippe?’ asked Tom.
>
> ‘Faith? It’s not a question of faith. It’s our lives.’
>
> ‘No, but you have to believe in it, that it’s worth it…’
>
> ‘It isn’t a question of faith. This is how it seems to me at the moment.’

Maïta poured the last of the dessert wine into Philippe’s and Tom’s glasses. She spoke as she did so:

> ‘There’s no hurry for us to discuss what might or might not be. We have a clear idea of the technology we plan to utilise and how we believe it can be marketed.’
>
> ‘Yes, but Philippe is saying something we all have to hear and consider.’ Tom looked from one to the other. ‘Do we want to do it?’

If you are brought up poor, you would enjoy a bit of money. You would be able, given a moment’s reflection, to find ways of spending it. You might even be nurturing in the back of your mind a pattern of spending for a particular purpose – perhaps an evening class, or child care so that you could work, or funds to start a business.

But if every penny had to be begged, wheedled and cadged from a distant and – to your mind – rather arbitrary authority, you might become weary and settle for your lot. No one likes to be constantly obliged. No one enjoys constantly having to ask, never receiving as of right.

Tom, Maïta and Philippe were sure that their plans fitted into the category of the ‘greater good’. They believed they were worthy of support. But within a fairly short space of time, they found themselves spending more energy and hours on asking for money than on doing the research.

> ‘You are happy,’ said Tom, looking fixedly at Philippe.
>
> ‘Is that relevant,’ asked Maïta.
>
> ‘He is. Look at him!’ Tom insisted, appealing to Maïta.
>
> ‘Is there any reason why I shouldn’t be happy,’ asked Philippe.
>
> ‘In my opinion, Philippe is always happy and we shouldn’t be surprised…’

Tom interrupted Maïta:

> ‘No, I’m saying he’s happy now and generally. With his lot.’

For, in all adversity of fortune, the worst sort of misery is to have been happy.

Boethius
Early 6th century

The three friends worked – jointly and severally – on laser micromachining. They found a niche in micromachining for medical products. They

researched and developed techniques providing minor but novel innovations in stents, filters, catheters and drug delivery devices. Maïta in particular collaborated with a Spanish university on polycaprolactone and polyglycolic acid, medical bioabsorbables.

Philippe found a research post in France. In constant touch with his friends, he enjoyed considerable success in the early days of optically controlled microsystems, nanomechanical technology having brought the scale of some devices down to a level at which manipulation by optical means became not only possible but desirable. Optical adjustment of the devices Philippe worked with gave opportunities for the finest of fine control.

Tom spent a couple of years on low-cost, high-efficiency lighting using LEDs. There seemed scope for this work to move into commercial production at an early stage – the prime impetus came from its suitability for lighting based on low-output systems, especially renewable such as photovoltaic electricity generation. However, the further Tom looked into the subject, the more he found it was already sewn up by large industrial corporations.

Tom took part in a couple of talking shops organised by well-meaning charitable or lobby groups. Meanwhile Maïta and Philippe had what appeared small satisfactions. These were insufficient.

The three friends met and emailed one another with ideas for independent research which, as time went on, became more and more commercial in nature.

> ‘I’m sure this is clever and to the point but…’

This time Tom interrupted Philippe:

> ‘Look, both of you. Do either of you think this will be easy?’
>
> ‘You mean the business,’ said Maïta.
>
> ‘Yes. Do you think it will be easy?’
>
> ‘People in education seem to think money is handed out for free in business, that only public services count pennies and justify expense,’ agreed Philippe.
>
> ‘What I’m saying is that you, Philippe, you are a happy bunny in what you are now doing. You like the idea of doing more. You wish you had more money, wider horizons of research. But if we develop one product over the next five years we’ll have done well.’
>
> ‘All our efforts will go towards commercialisation of a single idea, at least at first,’ said Maïta, catching on to Tom’s drift.
>
> ‘The focus will be narrower, not broader.’
>
> ‘Are you asking me to leave,’ enquired Philippe mildly.
>
> ‘No!’ Tom protested. ‘Believe me, I’m not. I’m asking you...’
>
> ‘What exactly are you asking me, Tom?’
>
> ‘It’s quite straightforward. I’m suggesting that you are happy now. You are not dissatisfied.’
>
> ‘And…?’

After much to-ing and fro-ing, the friends decided that their fields of inquiry allowed one particularly promising field – a field which not one of them would have anticipated.

Someone once said that a metaphysician was ‘a blind man in a dark room, looking for a black hat – which is not there’. Perhaps some theoretical science takes place under similar conditions. But the product Tom, Maïta and Philippe decided upon was very definitely there, a solid – though microscopically tiny – set of objects, found in nature and reproduced in the laboratory.

They imagined seeing their applications in TV shows of the sort that broadcast at prime time several nights of the week. They could conceivably be found on products advertised in the commercial breaks of the most popular programs.

> ‘Look at us,’ said Tom, his glance taking

in Maïta, his voice layered with sympathy. 'We're chewing our nails to the quick. We are in prison. We have done nothing but science for ten years. We think it's important but we have to beg for money to tick over. Our insights are theoretical and our impact on the real world is negligible.'

'Is that not the same for me?'

'The world you are working in is your world. You are at home there.'

'My achievements are significant in that area?'

'Whether or not they are – and of course they are – the important thing is you are happy with them and when you find yourself confronted with the frustrations of commercial life, you will look back and say: "I was happy then."'

Wing colours in butterflies appear in two types, pigment and structural, sometimes on the same individual. The pigment colours are produced just like zinc oxide gives us white oil paint. They are specific substances with specific chemical compositions. The structural colours, on the other hand, are produced in a different way.

The structural colours are created by scales on the insect's wings. If you touch a butterfly's wings, you will find the scales come away like powder. The scales are, in fact, photonic crystals.

Unlike pigments, which absorb or reflect certain frequencies of light as a result of their chemical composition, photonic crystals reflect light because of their surface characteristics. Photonic crystals can also be found on beetles and birds. The crystal array may reflect more blue light from one angle than another so the fluttering of a butterfly or the dash of a kingfisher will produce a beautiful array of colours. Perhaps these animals produce colours in this way because they find it easier – fitter for their environment – than synthesising large and complex pigment molecules.

'Do you want me to leave? Perhaps the two of you wish to discuss me further alone. That is my question. Am I out?'

'Philippe, I want you to know that I have not discussed any of this with Tom. Tom, I'm not sure if this is the way to bring this up. Do you…'

'I do not want you to leave.'

Using an electron microscope, it is possible to see a close-up of a certain butterfly's wing pitted with tiny holes. The holes form the photonic crystal structure and, although the wings are actually pigmented brown, they appear an iridescent blue.

As well as providing beautiful decoration, the iridescent photonic crystal scales are highly reflective. A layer of photonic crystals provides not only for brilliant visual display – clearly one of the goals of the butterfly – but also resistance to overheating from the rays of the sun in hot weather.

'I do not want you to leave and the things I'm saying apply almost as much to me and to Maïta, too.'

'What things, exactly? Can we be very precise now?'

'Yes, Tom, we must be sure what you are saying.'

'Is it so hard? I'm worried.'

'Worried about what?'

'That I haven't got it in me.'

'Got what in you, Tom?'

'The initiative. The gumption. The independence and the perseverance. You know. Don't you worry?'

'Ah,' said Philippe, reflectively. 'I see.'

'Yes?' asked Maïta.

'Tom is telling a story about me because he thinks it must be how we all feel to a certain extent.'

'That's it,' said the Englishman.

'Tom is explaining how he feels. He is

saying that he will, after six months in the cold blast of the icily arbitrary winds of commerce, feel like running back to the shelter of the igloo of academia.'

Maïta laughed aloud. The tension was dispelled in an instant.

Approaching the problem from different directions, combining their talents and resources, Tom, Philippe and Maïta managed to develop a way of manufacturing photonic crystals. They also believed they could sell them.

They stood at the brink. Would they take the plunge together?

'You're making fun of me now,' complained Tom.

'I am, Tom,' admitted Philippe, 'I am.'

'There were better ways to ask the question?' chided Maïta.

'There are. But now I have asked it, tell me, do you think like that, like me?'

'I have never thought that I would continue for a whole lifetime just as I am, tomorrow just like yesterday. Is that a good answer?'

Philippe laughed aloud himself.

'If you had given me some hint of your thoughts, Tom, I would have approached this question with less anger and more, well, no… ultimately less hilarity.' He and Tom looked at one another. 'You have been candid. Let me put it simply. The applications we can envisage with the technique at our disposal are commercially desirable and, we believe, viable. If you will give me your hand and promise to stand up for me and for Maïta as we will promise to stand up for you and one another, for the sake of the shared ambitions of 20 years of friendship, is their any reason why we should not leap into space together?' Philippe held out his right hand.

Tom took Philippe's right hand in his. He crossed his left hand over his right and offered it to Maïta. She took it and, crossing her arms too, she linked up with Philippe. Their arms they made a kind of crystal bond around the small lunch table.

As did their smiles, as they nodded and laughed.

The magnetic trains hummed rather than roared into the vast shed of the rail terminal. The atmosphere – both literal and figurative – of the great commuter intersection had been transformed since the public rapid transport vehicles (PRTV) had ceased to run on steel tracks impelled by electricity or diesel and friction. Now the PRTVs hummed suspended by a finely controlled electromagnetic field a few centimetres from their track, impelled by changes in the field to enormous speeds but with a completely smooth ride.

The absence of pollution – at least of particulate pollution – has meant that the glazed atrium over the vast concourse remains clean, allowing the play of sun, moon and artificial light to bathe the area in changing moods.

Times have changed on the concourse at Victoria Station in central London, too. There have been, over the years, many different outlets.

A unit appeared which housed racks of silver, heatproof bags for transporting ready-to-eat meals. The idea was that commuters would order their evening meal on the way through the station in the morning and pick it up in its special reusable packaging on the way home.

In the first decade of the 21st century, an enterprising business group created a modular shopping experience with a tiny footprint which, however, contained all the most important lunchtime destinations for harassed office workers. It was like a small walk-in arcade containing five tiny retail units: a sandwich and snack outlet, a dry cleaner, a counter with three public computers, a cash facility and a coffee machine. The entire unit could be lifted out and moved if the location proved unsuccessful.

Of course, the key and heel bar was a permanent fixture, while cheese shops, knicker emporia and so on ebbed and flowed with the tides of commerce.

Three years and two months after the conversation in the restaurant, at which Philippe, Tom and Maïta committed themselves to their business idea, a new outlet appeared – Crystal Bond. Rather unpropitiously, it was sited between a pub and the entrance to the underground toilet facility. The three of them sat, looking for all the world like a group of nervous travellers, perched on stools around a tall table. Maïta twitchily fingered her personal communicator, clearly awaiting a message. To pass the time, she opened the device clam-style and unfurled the soft keyboard from within. Her fingers barely stroked the touch-sensitive pads as she typed.

> 'Why don't you use VR,' asked Philippe. 'I use mine in English and French. I have it well trained.'
>
> 'This way, I start editing at the same time as I type. The text is cleaner straight away.'

On this, its first day, Crystal Bond was staffed by a single technician – found by Tom through his old department. In front of the outlet were two actors, dressed in the most extraordinary iridescent clothes. Their pierced ears were studded with remarkable jewellery which seemed to move as they moved. Their eyes were hidden by sunglasses which reflected the light of the concourse in a range of sparkling chromatic effects as they cavorted and sang to grab the commuters' attention.

At her stool in the pub, Maïta spoke a password to her communicator and was immediately in conversation via the device on her left ear. After just three or four sentences she nodded to her colleagues:

> 'It'll be here by lunchtime.'

The day chosen for the grand opening was Valentine's Day. It was an inspired choice.

A man dressed for the office entered the outlet. After a few words with the technician, he put down his computer case and sat at a carefully constructed console. The technician stood behind his chair. At an instruction from the technician, the man took hold of a joystick located in a smooth dark panel in front of him. The technician reached his arm over the man's shoulder, helping to guide the joystick in his hand.

After a few moments' practice, the man reached into a zip pocket on his blouson. He removed a small book. The book was entitled *Thoughts of Love*. The cover was made of stainless steel and glimmered faintly. He handed it to the technician who turned the pages of synthetic ivory and smiled indulgently at the sickly sentiments within.

The actors had gathered three more people into the compact outlet. Adopting more of a showman's persona, the technician raised his voice.

> 'Place the object in the hatch…'

As he spoke he took the book and, flipping a switch, inserted it into a metallic chamber located alongside the screen. As he shut the door, a cartoon rendering of the book appeared.

> 'What else can you put in there?' asked one of the rubberneckers.
>
> 'Almost anything metallic. If the substrate is inappropriate, the machine computer will tell us.'

The man decorated the cover of his book using the on-screen colour swatches and the joystick. In just five minutes he had covered the cartoon book with his personal message of love and several symbols. The technician pointed to the screen. The man – who was a little short-sighted – peered forwards and recognised a touch-sensitive button: *Finish*. He touched it.

Almost instantaneously the door of the chamber swung slowly open. The technician invited the man to reach in and retrieve his book. He did so and, as he pulled it from the chamber, turned it in his hand, watching the colours that were not colours ebb and wax.

Over the next two hours, 12 more people used the Crystal Bond outlet. At lunchtime there was a queue of users – who had come specially to see the new facility having been alerted by friends who had passed through that morning – and others who craned their necks for a glimpse

of each miraculously quick plating technology.

From the point of view of the three friends, perched on their uncomfortable stools, the morning's business could not have been more successful. As the group around Crystal Bond began to thin, Maïta took another message and slipped to the floor.

> 'Here it is,' she called to the other two, who followed her to the centre of the concourse.

From the main entrance, a large ramp was wheeled into a dominating position in the centre of the warm floor tiles. Once in position, a faint hydraulic hiss signalled the lowering of the ramp from its wheels to the floor. Then an electric car followed onto the concourse.

The day was bright but cloudy. Through the vast, high, glazed atrium roof, sun and shade flickered overt the shimmering surface of the electric car. In response the panels of the vehicle shimmered into mesmerising brilliance.

Maïta, Philippe and Tom looked around the fascinated faces of the onlookers and then into each others' eyes, and nodded and smiled once more.

On another bright day three years hence, an electric car flashed quietly through a speed trap. The iridescent sheen on its metallic paintwork confused the digital imaging device which declined to capture evidence of the vehicle's identity.

The bright sun was uncomfortable inside the electric car; Maïta twitched the rearview mirror. With one eye on the road, she adjusted a dial on her personal communicator. The device communicated wirelessly with a power source in the lining of her suit. Imperceptibly, her clothing lost its reflective sheen and became light-absorbent.

> 'Conference,' Maïta spoke clearly to her communicator.
>
> 'Ready,' came the tinny reply, amplified by the in-car speakers.
>
> 'Tom, Philippe.'

After a few seconds, both voices were on line, greeting Maïta and one another. They dealt with some outstanding business details – a licensing opportunity for another industrial application and staffing issues at their headquarters. Then:

> 'I've had another idea,' said Maïta.

Ed the Brain Reader

The magnetic train hummed into the terminal. It was one of the newest public rapid transport vehicles (PRTV). The ride was as smooth as a slide in a child's playground and, on acceleration to 500 km per hour, just as exciting.

The PRTVs floated on a finely controlled electromagnetic field a few centimetres from their track, rather than rattling along on rails. It was anticipated that the wear and tear on these vehicles would be so minimal – air friction, internal damage from passenger use – that they would last as long as the tired old stock they had replaced.

As the train slid to a halt and slowly settled on its track and vertical buffers, the Chief Executive Officer ran her chair to the sliding doorway.

A prison is an uncomfortable place, she thought. There must be job satisfaction, but…

It was a privatised institution, one of three for which she was ultimately responsible. But she was not here in a managerial capacity.

The PRTV came almost imperceptibly to a halt. The CEO's PA pressed the button for the ramp. Her mind wandered a little as her eye took in the grimy windows set like occasional wiry shrubs in the desert of the dull brown walls.

The CEO had been a teacher before entering business. Faced with a group of unpleasant schoolchildren, her satisfaction had been in making them a little less daft. But she had never taken full-blown pleasure in her work. There had been too much animosity – too much us and them – for that. Then, following her accident and the substantial compensation, she had invested in an MBA at Remote University, then had entered business by investing her own money, with some success.

The PRTV terminal was solely for access to the prison. She left her PA at the front security gate and met the prison officer delegated to show her in to the Governor's office. There was little ceremony and, as they left the platform, the Governor joined them for the brief journey to the medical wing. She was pleased; her reputation preceded her.

Time was – as always – pressing. There was a Board meeting later and nothing could be allowed to make her late for that.

The CEO and Governor Bingham arrived at a small, gloomy office festooned with cables and bursting with computers. The only light came from a pair of computer screens. One screen was paging through a sequence of photographs of people, places and things. The other displayed a set of graphs. Behind these two displays was a large plasma screen mounted on the wall. Faint shapes suggested that the screen might be turned on but that the lens cap was still on the camera to which it was connected.

> 'Dr Grayson, ma'am,' said the Governor to the CEO. Dr Grayson was beaming at her from a round, pink, flat face like a plate.
>
> 'Am I early or are you late?' blurted out the psychologist.

She was clearly nervous and regretted opening

her mouth the instant she said it. Governor Bingham stepped in urbanely:

'I'm sorry to have kept you waiting. Please go on, Dr Grayson.'

'Might I be allowed…?' The psychologist stopped again. She was unused to presenting her work to non-specialists and found it difficult to strike the correct tone.

'Dr Grayson has prepared a short introduction,' said the Governor. 'I would be grateful to refresh my memory, too. Ma'am,' she continued, meeting the CEO's eyes. 'I am absolutely sure that this visit will prove a defining moment in the war against terrorism.'

There was a faint shadow of surprise in the CEO's reply:

'Terrorism?'

The prison officer couldn't hold himself back.

'It's extraordinary, ma'am. The things we can discover. Sometimes even things they've forgotten. You'll see…'

'Is the volunteer, ready?' interrupted the Governor. The officer excused himself and left the dingy office. 'Terrorism suspects,' she resumed, 'are notoriously difficult to interrogate. Their minds are… confused where not entirely brainwashed. Reality and imagination are… well, how else would they commit the dreadful, indiscriminate acts we know them capable of?'

'This technique will pierce the mystery, ma'am,' put in Dr Grayson. 'You will see!'

'And, perhaps more pertinently, it will reveal that which the suspect intends to conceal.'

There was a pause. The CEO's eyes had narrowed with tension and there appeared a harsher glint to her eyes. It was clear she suspected her time was being wasted.

Then the three people in the office all turned their heads at once.

The panel behind the two computer screens abruptly revealed itself as a large plasma screen giving a view of an adjacent room. They saw the prison officer's hand move from the light switch and the flicker of the neon strips in the ceiling. The officer exited the room, then reappeared, helping what was obviously a prison inmate to the comfortable leather swivel chair in the centre.

The inmate sat back and the chair leaned a little under his weight.

'Is that man sedated?' asked the CEO.

'The technique at the moment requires the subject to be relaxed,' confirmed the psychologist Grayson.

'Dr Grayson has been working on this project for some time. This is the first time we have been able to encourage a member of the Board to see the results of this work. We are supported by the University research department…'

'Of which I am Chancellor…' cut in the CEO.

'Indeed, ma'am.'

'And of course the atrocity which led to your injuries should give you an interest…'

The Governor tried to cut the psychologist off in mid-sentence but was too late.

'You are suggesting that because I was crippled in a terrorist attack, I am likely to support future funding for your research into lie detectors.' The psychologist didn't reply. 'Lie detectors are, as you know, notoriously ineffective, less reliable than weather forecasting. I have read the data. I did not come to this meeting unbriefed.'

'No, no, no!' Grayson insisted. 'The briefing is out of date. This is not a lie detector. This is fact – or the extraction of fact.'

There was real conviction in the woman's voice and it caught the CEO's attention for a moment.

'Dr Grayson, I will give this meeting one more opportunity to reach some conclusion. But, please, it must be now and in few words.'

Grayson took a deep breath.

'A lie detector works on the basis of apparent physical signals; respiration, transpiration, dilation of pupils and so on. The process is in the hands of human so-called experts. They must interpret the evidence. They have attempted to systematise their patterns of work but have failed to produce scientifically verifiable results. As you say, ma'am, notoriously ineffective.'

The CEO nodded and glanced at her personal communicator to check the time.

'Yes,' Grayson continued, 'but this process is different.'

The psychologist turned to the screen and pointed with a stubby finger.

'There, you see Nabil applying the sensors to the subject's skull. You see. And here!'

The psychologist turned once more to the computer displaying the empty graphs. The three women watched as the graphics sprang into life.

'The sensors and the interplay of information they receive… together they create a three-dimensional picture of brain activity. When we began this work we thought we would be able to identify the thoughts a person was thinking by analysing those patterns of cerebral electrical activity. We applied so many sensors – more and more – you could hardly see the subject at all. For years your alma mater has studied along this track. For years. But of course they were missing the point.'

'The point, Dr Grayson,' prompted the CEO.

Dr Grayson turned to the large plasma screen showing the inmate volunteer in the comfortable swivel chair in the interrogation room. The three women now saw that the interrogation room was also equipped with a wide plasma screen on which a sequence of photographs was being displayed.

'These are the same photographs as…'

The CEO's gaze drifted to the computer on the table in the office.

'Yes, ma'am. At first a random sequence. Then, the database – the Electronic Detective, really, or Ed as I call it – takes over.'

'How?'

'The brain works by neurons sending tiny electrical signals. So, within your head, there is a mass of propagating electromagnetic waves. Ed's sensors know what the brain is doing – which neurons are firing – by collecting the electromagnetic near field "leaking" out of the head. Well, we found that of all the reactions – the mental reactions – there were one or two which we could recognise very clearly. Hunger was one. Not so much thirst, though we don't know why. We think it may have something to do with alcohol abuse and the subjects on whom we have been testing the procedure.'

'To the point, Dr Grayson,' Governor Bingham reminded the psychologist.

'Yes. Say, for example, Ed shows the subject a set of faces. Some of them we know are known to the subject. It is simple for Ed to learn the mental response that characterises recognition.'

'Ed knows when the subject has been shown something they have seen before?'

'Yes, but not just that. Ed can do the same thing with sounds.'

'Play a sequence of sounds in the same

way that he – it – pages through a sequence of images.'

'Yes, ma'am. But Ed is far cleverer than that. Ed can follow a trail. Ed can show a fixed sequence of images to learn about the subject's cerebral reactions – finding the "Aha!" spot if you like…' Dr Grayson laughed briefly at her own weak witticism. 'But then Ed can tailor the sequence – including aromas, possibly tastes, too, though we have not attempted that as yet – according to the last or previous response. Ed can search a database of literally millions of crime-scene images and lead the subject through them. If the subject gives positive responses to certain visual stimuli – colour or type of clothing, for example – Ed will search for crime-scene images that bear similarities.'

'And the result in this case?'

'Please bear in mind, ma'am, that the volunteer's identity has been concealed from Dr Grayson and her team,' put in Governor Bingham. 'The investigation they have carried out has relied solely on what Ed has been able to discover.'

'Yes, of course. I would expect nothing less.'

'Ed created a trail of images and some sounds which led to the, well, implication that this man is an abuser of animals,' said Doctor Grayson, with ugly confidence.

'I beg your pardon?'

'Oh… abuser in the sense of unkind. He has been imprisoned for cruelty to animals, serially, over years, repeatedly.'

'And could we not have found this out in another way?' the CEO asked drily.

'I suppose it could have been, but it wasn't, ma'am.'

'The identity of the subject was carefully kept back as a control to the experiment,' repeated Governor Bingham.

'What do you want from me, today, Governor?' asked the CEO.

'Permission to widen the research to a greater number of volunteers, ma'am.'

'Sedated volunteers.'

'At present we must follow that track, yes,' replied the Governor.

'I will reflect on the question…'

'One more thing, please, ma'am.'

'Yes, Doctor?'

'You may be interested to know that the volunteer…'

'Yes, Doctor?'

'He committed a rape and murder in south-east Southampton in June, two months before his arrest. He recognises the crime scene.'

For the first time the CEO was taken completely by surprise.

'Has he confessed it? Was he tried?'

'He has never been questioned in connection with this crime. In addition, we haven't confronted him with the accusation. We have no jurisdiction,' replied the Governor smoothly.

'No. of course,' replied the CEO.

There was a pause.

'As I said, I will reflect on the question.'

Dr Grayson was about to jump in once more but the Governor interrupted:

'Thank you, ma'am. For your time and interest.'

Within two months, as requested by the CEO, Dr Grayson submitted a complete report on the work she had carried out at the prison. The summary form ran to over 11,000 words.

In her office in London, the CEO's desktop viewer

was displaying security bulletins from a number of sources, Grayson's report being one of them.

The CEO had asked not to be disturbed. She flicked the mute button on the video link that showed her PA discouraging visitors in the lobby to her office. In the unnatural quiet, baffled by the thick sound insulation in all the walls, floor and ceiling, she scrolled a few pages.

It claimed that 62.7% of UK businesses had suffered a security breach over the last two years. Of organisations who considered their business information as 'critical or sensitive' 45.6% had suffered an 'extremely serious' or 'very serious' breach, usually the result of user error.

She opened another file. It covered a terrorist attack in West Africa. The country's security services had been on a heightened state of security, yet the British passport holders had been afforded VIP treatment – in other words, no intimate body searches. This was, apparently – her fault.

The CEO turned to her diary and dictated:

> 'Security is remarkably effective. Loopholes are few. Operators become careless, therefore, because the system appears so robust. For example, some years ago hard drives detailing US and ex-Soviet nuclear missiles were missing from Los Alamos for 21 days before they were reported. The site was so secure, staff believed the missing hard drives would turn up – that they had been misplaced like a set of car keys…'

Worse still – though not yet in the public domain – a group of nationalists in south-west China had recently penetrated a facility storing weapons-grade nuclear material and attempted to build a crude nuclear bomb. Security was not tight enough to prevent the terrorists gaining access, but it delayed the arrival of the security services themselves as their procedures were used against them. It was a matter of debate whether the incompetent bomb builders, given more time, would have succeeded in detonating their device.

The CEO's personal communicator indicated an incoming message by flashing its screen. The device resembled a wireless PDA in a clam design but was small enough to be worn on the wrist. Hers was lying on the desk alongside a soft roll-out keyboard for typing quickly and comfortably. When in this building, the wireless device had to be plugged into a fixed optical communications network or it would be useless. The whole headquarters was full of telephonic white noise to prevent mobile communicators from being used as remote detonators or bugs.

> 'Good morning, ma'am,' said the face on the communicator screen.
>
> 'Good morning, Governor Bingham. What do you have for me?'
>
> 'Would you like the video review or my summary, ma'am?'
>
> 'Your summary, please.'
>
> 'Dr Grayson's work with the University has been continued and developed. The purpose of the project – at first solely imagined as an Electronic Detective – has been broadened. All the same,' the Governor continued conversationally, 'the name Ed has stuck...'
>
> 'I understand the new designation is BR.'
>
> 'Yes, ma'am, for Brain Reader. But Ed seems easier to remember and use…'
>
> 'Go ahead, Governor. It isn't important.'
>
> 'The scientists' understanding of how the brain works has developed. The current version of Ed enables us to make much more direct links between what the mind is thinking and what the brain does when that happens.'
>
> 'And, therefore, to read the subject's thoughts…'
>
> 'In addition, ma'am, measuring brain activity also allows us to monitor physical and mental well-being. We believe it could be used to understand how the brain learns complicated processes, such as

learning to drive. Perhaps those processes could then be taught – or even implanted – raising the performance of poor drivers who would otherwise be denied a licence.'

'I understand that there are what we might call benign applications. What about our field, yours and mine?'

'At Ed's current state of readiness and sophistication, Ed could be used to identify terrorists on the basis of their thoughts prior to boarding a plane.'

'Is this feasible? What is the size of the device?'

'At this point in time, no more than a single portable computer with a fast data connection. The connection leads to a single device – rather like a helmet – in which the sensors are now embedded.'

'How many, out of interest?'

'There are 4,617 in the current version 6.9.'

'And how quickly can it detect? Is it feasible?'

There was a pause while the Governor reflected.

'Ma'am…'

'Yes, Governor?'

'This project is designed in the first place to lead criminals to confession. You wish it to perform miracles of prevention. I have no doubt that the technology will be capable of doing what you require. Perhaps soon. After all, even the portable device can use Dr Grayson's database – which we have continued to expand logging new crime-scene data on a weekly basis – by accessing it remotely. The results are startling. Since your authorisation, CID inspectors have cleared large backlogs of case work, based on these investigations. Our short-term detention area, as you know, is devoted to these investigations alone, because the database is accessible. Remote access is feasible…'

'And have you attempted unsedated subjects?'

'For the applications you seek – for prevention in the areas we have discussed – that remains a stumbling-block. But with willing subjects we might be able to use the technique in the treatment of certain mental health issues. Ed should be able to identify more clearly than human diagnosis the precise nature of specific mental illnesses. Ed may also allow us to track the mental state of potentially dangerous subjects – sexual criminals, for example. With close, periodic scrutiny by Ed, it might be possible for these people to remain in the community…'

The CEO glanced at a blinking message symbol in the corner of her screen. She touched it with her forefinger.

From: Market Preview, Department for Science and Future Technology

Subject: non-invasive brain reading

Message:

Market estimate £10 billion within 10 years. £100s of billions thereafter.

The CEO closed the message.

'Thank you for your involvement in this project, Governor. I understand your reticence. Be assured, your work has not gone unnoticed.'

'Thank you, ma'am.'

Neither woman closed the call.

'Ma'am?'

'Yes, Governor?'

'The device has become, effectively, a brain reader.'

'Yes, Governor.'

'May I ask what further you are minded to do with this technology?'

'I will reflect on the question.'

Tiny holes

Tiny holes can be important. Security is often a case of plugging tiny holes. You know they are there; after all, no system is foolproof. It is up to you and your agents to find the holes – not necessarily the bad guys – and stop them up.

I had my first lead from an experimental interrogation technique being trialled at one of the Remote University campuses. The campus was near a high-security privatised detention facility where some experimentation was being carried out.

Being Remote University, the premises were small, teaching rooms with no student access. Security here, therefore, was good.

I gained access to a corridor running along a set of lecture rooms. I like to take advantage of these opportunities to look around new environments, so, when I met one of the professors, I showed my ID and asked for a tour of the facility. He hitched up his teaching robes and showed me the technical room on the ground floor and the hatch in the ceiling leading to the multiscreen lecture room.

It also gave me an opportunity to quiz him about his colleagues.

> ‘Professor Miah,’ I said, clocking the identity panel on a wireless device hanging round his neck, ‘do you know of Dr Grayson’s work?’
>
> ‘In what way might I know her?’
>
> ‘Well,’ I took a guess, ‘you are both in the communications field. I thought…’
>
> ‘My work is concerned with interpersonal communications and data transfer and handling. I have never been involved in exploring the drugged consciousness of imprisoned criminals.’
>
> ‘No,’ I went on, ‘I suppose there isn’t much connection…’ I let the sentence hang but he didn’t take the bait.
>
> ‘I can tell you where to find Dr Grayson’s office, if you wish,’ Miah told me, stiffly.
>
> ‘Thank you. I have directions,’ I told him.

We didn’t really hit it off.

Grayson’s team had been doing some amazing work. They had a brain reader coupled to an evidential database that could track through a criminal’s memories and home in on things he or she had seen before. They called it the ‘Aha!’ spot. Apart from clearing whole caseloads of insignificant unsolved crimes, now and then – like a lucky hobby archaeologist – they found a real gem. And then they called me.

> ‘These are the faces he recognises,’ said Grayson, spreading three pages of A4 hard copy in front of me, four mug shots on each page. Each was identified by name and identity card number. Three of them were of interest because I already knew more or less who they were.

I sat through two and a half days of the same sequences of images Grayson and her team had shown the criminal-turned-informer. I suppose it didn’t take that long for the brain reader to show

them to the informer, but I had to read the evidence notes as I went through them. I got a feel for the organisation, what they wanted and what they didn't like.

The best part was where the brain reader system – they called it Ed for Electronic Detective – took the informer through location evidence. Again the database began its search with almost random images – photographs, drawings, maps. As Ed homed in, however, the psychologist Dr Grayson showed me how they had learned to distinguish between places the informer recognised from having been there and places he – or one of his group – were planning to visit. The brain reader detected a different sort of 'Aha!' apparently.

A harbour on the south coast of England.

At the end of the third day, I went to a privatised detention facility close to the Remote University teaching and research campus. This was where Grayson and her team had been interrogating detainees.

I met the Governor, another woman, called Bingham. She gave me escorted access to the informer who told me nothing.

Dr Grayson came with me. I was able to offer certain inducements to the informer if he should feel inclined to tell us more. Obviously the man hadn't realised what the brain reader could do but regretted submitting to the procedure. In any case, Dr Grayson was convinced she had everything of interest, but then a technologist will tell you there's no difference between a really good electric piano and one made of metal and wood.

Faced with the informer's refusal, I suggested we could go through the process as a legitimate investigative technique without the informer's permission, but it turned out the procedure only works on a willing or – for this we had no permission – sedated subject.

I took a public rapid transport vehicle direct from the prison to Southampton. The PRTV was virtually silent and, once it had accelerated to cruising speed, I slept. After all, the magnetic impulsion system moves you at about 450 km per hour and at that speed the view out of the window is a blur.

While I was on the train, I knew I wouldn't be able to communicate – the impulsion field is too strong for personal communicators. Also, like the prison, the trains are full of white noise to prevent remote detonation and so on. But I now more or less knew the general intended location of the attack and needed to put defences in place. Before leaving the privatised prison, I spoke to the Governor again and – as I suspected – she had a shielded room from which I was able to use my personal communicator to upload and distribute the intelligence I'd collected.

What comes next I was able to piece together only with hindsight. I was chasing behind them and time was not on my side.

A couple of hours before I left the prison and about 50 km from the PRTV dock at Southampton, two men and one woman brought a small craft into a sheltered bay. The navigable part of the channel into the bay, bounded by sandbanks even at high tide, was narrow. Luckily for them, the shallow draft of their vessel allowed them to slide alongside a much larger craft leaving the bay. This was an unexpected bonus for them as they might have expected to be challenged at this point. As it was, their entry into the harbour went unnoticed by the regular security staff.

My people weren't yet on the scene, of course. If they had been, they'd have clocked a word recognised under sedation by the informer. At the time, I just thought it was a hint at some kind of religious message: hope. From the deck of the larger craft, though, the name of the smaller boat could clearly be seen: *New Hope*.

After the channel, the bay was busy. There were many small boats – almost all of them leisure craft. The occupants of the *New Hope* were dressed for leisure too, although beneath their carefully chosen sportswear, they had on thermals and waterproof Gortex garments to protect them from the spray of the deeper waters they had recently – illegally – crossed.

The crew of the *New Hope* had taken advantage of the fact that it is difficult to police the seas. Up until recent times, pirates were rife in many of the world's seas and oceans. Only since GPS identifiers became mandatory have the international authorities begun to police the world's waterways more effectively. If a ship is obliged to have a unique recognition code linked in to its GPS equipment, it is a simple matter to ensure that a database of sea-going craft is maintained and updated. Any vessel not on the list – or unable to respond to a request for GPS-based identification – can be stopped and searched. And then possibly impounded and the wrongdoers aboard arrested.

However, boats travel in and out of small ports each day without GPS identification. They are small enough not to be required to have the system on board by law. For me, it should be like the register of personal communicators which are all unique-coded and linked to identity card numbers to deter theft. However, boats registered for inshore use aren't required to join the system and, although I don't know for sure, it must be a loophole which is routinely exploited.

Sometimes, where shorelines converge and small distances on sheltered waters can be crossed in favourable weather, this loophole can allow contraband or dangerous goods or people to be moved from country to country. Chains of islands can be exploited to smuggle large distances by island hopping. In the case of an island nation, the problem might not be with illegal international imports of contraband items or people, but relocation within the country itself. For example, a facility on a shoreline – such as a power station – might be vulnerable to attack from the sea, from a small craft launched from a nearby leisure port.

Like I said earlier, there are blind spots and blind times in any system. In the case of the GPS system, some atmospheric conditions can cause signals to be lost. Equally, demand for signal time has expanded enormously since the inception of the systems at the end of the 20th century and periodic downtimes have become – if not common – a repeated occurrence.

The final and most important loophole, though, is the availability of a ship to intercept a suspicious signal or a no-response. Money and staffing levels, obviously.

The distance travelled by the *New Hope* that morning was just 25 km. Winds were light and the small electric motor meant they had spent nearly three hours on the water already. Yet they had not been intercepted.

In the United States of America, colleagues of the *New Hope* crew had launched a mammoth set of GPS tracking demands over the public internet. They had access to high-speed optical communications nodes – possibly in educational facilities or businesses – and were able to send and request massive droves of data. Concentrating all the processing power at their disposal, they managed to launch a denial-of-service attack that had created sufficient blind spots to allow the *New Hope* to pass unchallenged from an offshore island to the mainland. Now the craft was in the bay, it was unlikely that they would attract attention. They were, in any case, legal once more.

The bay served three different sets of public moorings, each with its own sailing club. The popularity of sailing is a response to the decline of motoring.

The internal combustion engine was an exciting technological development. For years, the world's developed economies were powered by explosive fuels. More recently, electric and hydrogen cell vehicles have taken over the roads, removing the buzz of acceleration, noise and personal control from travel. Even the small commuter planes that a few years ago replaced long-haul flights in short hops were quieter than their early 21st-century predecessors. Whereas in the 20th century, fast driving of explosive-fuel private vehicles was the acme of individualism, today's alternative and renewable technology emphasis means that sailing has become the new petrol.

Alongside this, the onset of global warming has made sailing an occupation that people find amenable for more of the year. Warmer temperatures more than make up for the larger

number of rainy days. And, of course, increased winds make for more exciting speeds, albeit much slower than the old combustion and compression engine hobbies.

I later discovered in person that the *New Hope* headed up the bay and found a mooring alongside the smallest of the three sailing clubs. The three brought their small craft up as close as they could to the jetty. They gave the appearance of lounging holidaymakers. They seemed from a distance to open a picnic hamper and drink heartily from bottles of champagne. They were audible but not noisy. After an hour or so in the receding tide, the *New Hope* was beached in the mud, standing level on its twin keels. One of the two men put on a suit, stepped into Wellington boots and waded across the mud to the shingle and slime beach.

I later spoke to a member of the sailing club who noticed the stranger. He told me that there was something odd about the clothes he was wearing.

A metre-high concrete retaining wall lined the short strand. The man – who was bearded – vaulted onto it and took a couple of steps into the pub garden. He took a seat at a table in the shade of a communications mast. It cast a grid of grey lines across the back of his pale sweatshirt, like the bars in a prison window.

He was joined by another man with dry skin and violent red hair, brushed wirily away from his forehead. No one knew it at the time, but this was another of the faces on Grayson's printout. We picked him up early in the operation.

After just a moment the two men crossed the garden and the car park and made their way into the dry dock. Four boats stood on rough wedged wooden props and two on more sophisticated hydraulic lifts. All six sported large solar arrays capable of capturing enough energy to run water-purification systems, plus navigational and microwave cooking needs.

In addition, the photovoltaic cells provided energy for a small chemist's laboratory equipped for the synthesising of artificial chemical odours.

The two men climbed a ladder leaning up against the side of an 11 m boat that had, simultaneously, an air of undergoing a refit and being thoroughly lived in, with laundry hung out to dry all along the rails. The red-haired man and the bearded man from the *New Hope* disappeared below deck and, five minutes later, the bearded man emerged with a rucksack on his shoulders and made for the sailing club perimeter fence.

Still my people weren't on site.

There were dogs at the gate, which was open at this busy time of day. They had a single handler and were allowed to range on long – 20 m – leads, more like lunge reins for horses. They jumped up at the bearded man, who took care not to meet their eyes and kept a steady pace. The dogs were surprised to discover that he smelt just like them. Their surprise soon turned to disregard when the man paid them no attention. He walked with impunity away from the harbour, his rucksack on his back.

Of course the bearded man was carrying the explosive device. It wasn't particularly sophisticated but then, of course, destruction isn't often sophisticated. And among our problems was the fact that the location of the attack was, at this point, unknown. As was the means of delivery.

Within the hour, the other two occupants of the boat had also left the harbour. There was no reason for them to be stopped and they were carrying nothing more than the clothes they stood up in and personal effects in their pockets. Once out of the harbour area they went their separate ways. The second man has not been tracked down as yet. The woman – had we known it and had we been on the spot – was our target.

So, that pretty much brings us up to date. I'm on the scene at the harbour, gazing at a low evening sun and nervously checking the time every 90 seconds on my personal communicator.

I have a pretty good idea that I have missed the boat – literally. The regular users are being

quizzed about any strangers to have come through the harbour. That's when we get the lead about the odd suit the bearded man appeared to be wearing. We found someone who noticed the guy wade through the mud to the harbour wall and that gives us an idea of what area of the bay to look for the boat. I squelch out myself in a pair of borrowed waders and… Bingo!

'*Hope*.' The *New Hope*!

Aboard the boat, we make a thorough search. We find little of interest as they appear to have taken everything with them. Then, stuck to a corner of the deck by the spray, we find a wrapper from a popular anti-nausea preparation. Of course, at first we connect this with the boat and sailing.

Now, if Ed the brain reader is the latest thing in interrogation techniques, the DMS is the equivalent in identification.

DMS stands for DNA molecular screening. I've been involved in its roll-out and I've followed the science that has made it possible.

It's a form of molecular spectroscopy. It can identify single DNA molecules and works by capturing the individual molecules of DNA in microscopic pits in a metallic film. It's based on the lab-on-a-chip devices used for all those pharmacogenomic therapies in hospitals. The molecules are then processed in situ – the device has been portable for the last three months – using proteomics, causing the DNA to react with something I don't understand but which gives us – so they say – a 'fingerprint'.

We gathered the DNA data and I adjourned to the public house on the quayside, leaving the techies to process in the truck. I had no ideas and I thought that I might perhaps hit on something in conversation.

Darkness fell. For a good 90 minutes it was just chit-chat. Then it hit me.

> 'Yeah,' drawled a guy in a blazer propping up the bar. 'Overweight. I hate to see that in a woman.'

I put that together with the list of targets I'd been considering from the local police data, added the anti-nausea tablets and knew what to look for.

Of course, while all this had been going on, the bearded man had been heading for a rendezvous with his female accomplice. (Like I said, the other guy was just a red herring.)

The woman had checked in and had been given a room. Our bearded friend made his way to the perimeter of the facility and searched for some point of access. This wasn't too hard to find, as the management's idea of security was large under-occupied grounds patrolled by loose dogs. And we already knew that our man was dog's best friend.

Once in the grounds and having made friends with the canine defences, our man made his way to the outskirts of the clinic. There he was under surveillance from an intelligent but unstaffed digital CCTV system. Unfortunately, this is where his special suit came into play.

The suit had been noticed at the harbour as just 'unusual'. Not 'bulky', or 'foreign-looking'. It was to do with the fabric somehow. When we recovered it later, we found that it was hooded and the material of which it was made included a weave of metallic threads plated with photonic crystals.

Now, you may or may not know that photonic crystals are capable of all sorts of remarkable visual effects, including confusing digital camera technology. They have been used as a way of hiding speeding vehicles from roadside speed-control cameras, for example, although now that fast cars are a bit of a thing of the past the market for photonic crystal plating of vehicles has collapsed somewhat. In this case, hood up, the photonic crystals in the suit prevented the artificial intelligence running the surveillance system from 'seeing' him.

At the same time as the man carrying the explosives was approaching the windows of the residential rooms, I and two operatives arrived at the main gate. Gaining access to the site took us precious minutes as security procedures

were gone through. It had crossed my mind to try and enter clandestinely, but I wasn't wearing Eau de Chien.

Normally it's easy to 'see' explosives at terahertz frequencies but – of course – I didn't know exactly where the guy was at this point. And in any case, we found out later that the rucksack was lined with the same metallic stuff as his suit, which would have blocked the signal. But as soon as we had got hold of the explosive, the full hyperspectral functionality in my spectacles managed to pick up enough of a signal for the data analysis software on my personal communicator. It was the same chemical composition that was used for the fairground attack last year.

I didn't have sufficient numbers to storm all the rooms at once – there were 37 women resident in the clinic – and I was worried about turning the thing into a suicide attack. I wanted to pin the guy, before he had time to pass the explosives on to his female accomplice and without him having an opportunity to set them off himself.

Fortunately, their cunning plan of attack had a flaw.

The target was an obstetrics clinic. Their purpose was to kill as many of the women in the facility, along with as many of the medical staff as were within range. In order to gain access to the site, the female accomplice had registered for a termination – she was, of course, pregnant and had been taking the anti-nausea drugs for morning sickness. Using the hyperspectral glasses, I might have seen that through her clothes if I'd just got to the harbour a mite sooner.

The flaw in their plan of attack was the registration process at the clinic. Although she was able to come up clean on all body searches, she was obliged to leave blood and urine samples with the medical staff at check in. When I arrived with the DMS device, I was able to identify her by screening the DNA in her samples and matching it to the DNA we found on the *New Hope*. Then we were able to locate her room and move in on her alone.

We were not a moment too soon. We entered dressed as medical orderlies at the very moment our bearded friend was climbing in through the window. One of my two associates restrained the woman while the other one helped me pull the man into the room. The rucksack was still on his back and – thank heavens – he had no way of detonating the device at the last minute.

In this special case, conditions for the use of Dr Grayson's brain reader were relaxed. The subjects were interrogated against their will under sedation. We discovered that the plan had been for the bearded man to hand over the explosives and slip away, leaving his accomplice to kill the largest possible number of victims by sacrificing herself and her unborn child.

The suicide attack was to take place at the assembly point for a fire alarm – a fire alarm she would, herself, set off.

So, success. Just.

As I said, tiny holes can be very important.

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