Enabling the Digital Economy: The Third Wave of Wireless

The UK has played a leading role over the past 25 years in creating and establishing what has become arguably the world's most globalised industry, an industry which continues to experience rapid and radical evolution. From humble beginnings today the UK is home to major operators such as Vodafone and BT, it hosts telecoms R&D from Japan, Korea, China and the USA, and is home to enabling companies such as ARM, CSR, Ubiquisys, picoChip, ICERA and others, as well providing world leading academic research to the global industry[1]. Recent and ongoing developments promise the potential to transform industries and public services; such change however will not be without challenge, a challenge which is not simply technological, but also cultural and organisational.

Countries worldwide are seeking economic growth whilst reducing public spending. In this environment, wireless offers the prospect of new capabilities, efficiencies and business models which can enable the long-awaited 'digital economy' in areas as diverse as enterprise, healthcare, transport and energy. Governments have a central role in this, not financially, but in perpetuating or helping to remove the barriers to change; the opportunity for government is to work with industry to remove the barriers to new ways of delivering public services and new opportunities for industry growth.

Introduction

The consumerisation of wireless technology was triggered only 25 years ago, with the advent of cellphones. The promise of a mass market triggered huge and sustained investment, drove down costs and opened global markets. Today 80% of the global population have a cellphone, more than 5bn subscribers worldwide. In Europe most countries have 100% penetration rates; in India and China, penetration rates are 50% and 63% respectively.

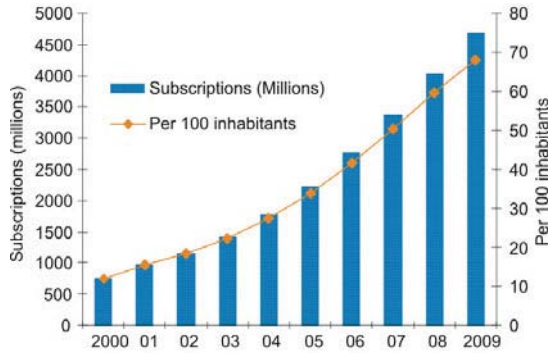

Figure 1: Growth of the Global Cellphone Market, 2000-2009 (Source: ITU)

Telecoms has long been acknowledged by World Bank studies as a key driver of economic development; more recent work has confirmed the important role within this of both cellphones and Internet access [1, 2]. With the arrival of mobile Internet, we can expect to see further global acceleration in economic development.

What however lies beyond, as these global markets for mobile voice and Internet begin to saturate ? Where will wireless go next and what will be its impact ?

Evolution of an Industry

It is sobering to consider how recently the fundamental principles of wireless were first discovered, at the end of the 19th century. Practical use of the technology began in the early 20th century for naval and air communications, with commercial radio and television broadcasting taking off as a result of military developments during the first and second world wars respectively. Yet, 40 years later, as recently as 1985, almost every telephone on the planet was still connected to the network by a wire. Change since then has been rapid; and the pace of change in wireless continues to increase.

The First Wave of Change: Mobile Voice Communications

In the 1980s the latent consumer demand to talk to others wherever they may be began to be addressed, by means of various national cellular radio systems. The early success of these analogue networks triggered development of digital systems - regional solutions - PDC in Japan, TDMA and CDMA systems in North America and the 'Groupe Spéciale Mobile' (GSM) system in Europe.

By the mid-1990s the first wave of consumer wireless, digital voice telephony, was finding rapid take-up in Europe and was being recognized in the developing world - although at that time costs were still too high for mass deployment in those regions. As time passed,

GSM was increasingly adopted outside of Europe, eventually even in the USA, reflecting its eventual change of acronym to 'Global System for Mobile'. The resulting economies of scale accelerated its affordability and adoption in all parts of the world, delivering a basic telephony service in countries that as recently as 2000 had possessed a minimal communications infrastructure. GSM became an enabling tool for economic development [1].

The Second Wave: Mobile Information Access

3G research in Europe began in the mid-1980s. Standards for European 3G, then called UMTS, were developed alongside the deployment and growth of GSM in the 1990s. At this time, of course, the Internet was emerging from the military labs and entering the public consciousness. Early 3G research had envisaged the role of data communications to the cellphone, but the pace of commercialization of the Internet created new possibilities. Mobile messaging (email) had been seen as the first widespread application, but suddenly the potential market was much larger, both in terms of applications and of geography, as Internet usage was going global.

Initial European 3G services at launch in 2003 were conservative in terms of data rates, and mobile Internet was slow to develop, pending upgrades associated with High Speed Packet Access, HSPA. Availability of HSPA dongles in 2007 triggered take-up of mobile broadband, initially driven by PCs, especially in their (more portable) Netbook form factor.

The advent of 3G smartphones with large colour displays and touchscreens further stimulated take-up of mobile Internet. These suddenly enabled download of new applications, enabling phones to perform many useful new things at the whim of the user. The so-called 'Apps Stores' were actually not new - Palm had introduced them, via the PC, for its personal digital assistant products years previously; Nokia had supported its early Symbian smartphone products similarly. However, hidden by complex and hard-to-use menus, Apps Stores were invisible to most consumers and their potential untapped until the advent of the improved user interface.

A second stimulus to mobile Internet was the move away from the 'Walled Garden' philosophy. Mobile operators had originally anticipated the opportunity to offer their customers a limited range of proprietary services, a 'walled garden' of chargeable services, rather than giving open access to competing offerings; they had not anticipated that they would (quickly) have to go 'open'. The concept of open Internet was implicitly promoted as part of WiMAX, a technology driven by Intel as part of entry into the wireless market. Intel had conceived an open ecosystem of wireless-enabled products - e-Readers, e-Cameras, etc, not just cellphones - available via high street stores, not just via mobile operators. Whilst as a mobile technology WiMAX is being supplanted by TD-LTE as a successor of 3G, the wider product ecosystem ideas have endured.

Today in developed markets, mobile broadband, built upon the open Internet model, has become an important revenue stream for mobile operators, providing income growth to complement falling voice revenues. Across the globe major traffic growth is reported, with recent industry forecasts for the growth of mobile broadband traffic over next 5 years ranging from 30-40x [3].

In developing markets, mobile Internet access is potentially hugely important. For many users the mobile phone will be the first, and quite probably only, device they use to access the Internet. As such, its contribution to education, healthcare and economic development in rural areas promises to be highly significant.

The Third Wave: Personalisation - and the potential for Industry Transformation

Wireless has followed the development trajectory of wireline telecoms - telephony, followed by data. Today wireless is an integral part of telecoms; the early divide between wireline and wireless has largely disappeared. Most telcos today provide both forms of service whenever they can. However, a wireless device offers unique features which fundamentally differentiate it from a wired phone or a wired Internet terminal. A mobile device is owned by an individual user; as such, the device, and the services it supports, can be personalized, adapted and optimized to the needs of the individual user. The importance of this, in terms of advertising potential, was recognized early by Google and was the driving force behind its development of the Android operating system, as the company sought to translate its highly successful Internet advertising model into the personal, mobile, space.

The growing compute power of the mobile device - phones with 1GHz CPUs are already here - means the phone can increasingly harness and mine data, to infer contextual information about the user, from his behaviours, from the content flowing through his device and from its time-varying location. This means, for example, that:

- through access to my electronic diary and learnt device usage behaviours, it can infer my current 'role' - am I in business or family mode, for example
- through knowledge of my calls, texts and email patterns, it can build a model of my social network
- through mining the information content of those calls, texts and emails, it can learn my interests and priorities

By combining such knowledge with realtime location it can provide new types of unprompted assistance services - eg knowing my next appointment (from my diary), the current time, my current location and by inferring my usual travel behaviours, it can provide timely yet unprompted travel directions.

At their simplest, such services are a small step from today's Apps - however, getting the usability right (ie not the 'Microsoft Office Paperclip') and providing acceptable privacy guarantees, will be necessary for such intelligent passive services to gain mass market acceptance. Functionalities such as identity, presence, automated discovery of devices, infrastructure & services, and micropayment mechanisms are also required, and increasingly available, along with new forms of trust, privacy & permissions (simple to use, but informed, consent).

Looking beyond this next stage, we see users increasingly possessing multiple wireless-enabled devices. Examples of recent such devices, which are already appearing, are given later. These devices may be enabled by Bluetooth, WiFi, 3G or LTE, reflecting their application, range and data rate requirements.

We also anticipate users interacting with increasing amounts of wireless-enabled public, and personal, infrastructure, thereby enabling yet more powerful functionalities and services. In the home we expect to see increasingly use of femtocells, probably supporting WiFi and Bluetooth, as well as 3G and/or LTE.

Significantly, we may also see user services which integrate content, capabilities and information belonging to multiple service providers, not just telcos, through the use of open and closed APIs. Such providers may be broadcasters, Internet players, banks, hotels, transport, education, energy, health or other private or public service and/or information providers; new providers will emerge. At this point, service evolution and the impact on other industries starts to become significant.

Transforming Industry, the Environment & Public Services

Just as mobile phones have transformed person-to-person communications in business, and as the Internet has enabled new IT infrastructures, so combining these wirelessly with realtime personal context - the third wave - offers the potential for a significant further evolution to enable the digital economy.

The shape that such evolution will take and the opportunities offered by intelligent, wireless-enabled, contextualized services are many and varied, as illustrated by the examples below. Most significant is that wireless offers solutions to some of the big challenges facing our society and economy today.

Enabling Enterprise

For some years, RIM built its business as a leading supplier to the white collar enterprise market of secure email communications to field staff. Responding to recent changes with its own touchscreen devices and apps store, RIM is today seeking to widen its capabilities. The capabilities offered by the new and emerging technologies mean both new competition and new opportunities.

Enterprises today need be fluid and agile, creating ad-hoc teams to address new opportunities, and the ability to respond rapidly to sales opportunities; yet many businesses still lack the ability to rapidly identify the right people to staff such temporary teams and the tools to manage them. Much knowledge within a company still resides as tacit knowledge within the heads of their employees; finding who knows whom and what is often, even today, done via the 'informal network' rather than via an (often out-of-date) company database. This is where the combination of contextual, social network and behavioural information flowing through a user's devices could deliver new capabilities to the enterprise.

Corporate privacy is essential for acceptance of such services, along with respect for the security of information rightfully owned by the employee himself and for any information provided by the mobile operator - the need exists to harness and intelligently use such information, owned by different actors, in a demonstrably secure manner. For some low security applications, a single centralized server could be adequate, whilst for more sensitive scenarios processing on an individual user's device could be more appropriate, utilising blind-matching query-response interactions with secure databases owned by the corporate organization and/or the mobile operator. Architectures appropriate for the small or medium enterprise may be different from those for a large corporate client, as could business models, but in both cases data security should match the commercial needs associated with the contextual-, social- and content-based information enabling the service.[2] Looking beyond initial applications, such services could change both business processes and, even, business models.

Public Services in a Connected World

In many ways public services resemble the model adopted in the past by telecom operators, where a new infrastructure was designed, created and deployed for each new service - the 'stovepipe' model. This severely constrained interworking and evolution of services, as well as limiting the potential for economies of scale. The geographical devolution of responsibility for public services to Local Authorities and Regional Development Agencies has, similarly, historically resulted in the emergence of different regional approaches and solutions. Seeking to fulfill their remit of fostering

growth of local companies, RDAs have encouraged development of new, non-standardised, solutions, resulting often in good technology, but solutions which cease to work outside the local area.[3]

Recognising this problem, government has also sought national solutions, in the area of healthcare, for example, only to be faced with large scale, over-budget, IT projects. The emergence of the wireless Internet perhaps offers a new approach, creating opportunities to use standardised communications infrastructures to support a multiplicity of applications. Such solutions may however emerge bottom-up rather than top-down, just as in-car navigation services emerged initially via TomTom satnav products available in the high street, rather than as services provided by the Highways Agency, or even the mobile phone operators.

Enabling Healthcare

Figure 2 WiFi Body Scale by Withings [4] (Source: Withings)

Healthcare or, more precisely, wellness, is an area where such developments are already underway,[4] where early manifestations of the 'Internet of Things' can be found, in the form of products such as the Withings Body Scale [4], the FitBit [5] and the Nike+ products [6]. The Body Scale is a WiFi-enabled device that automatically measures and uploads weight and body mass index to allow personalized tracking on the web.

Figure 3: The Fitbit Sleep & Exercise Monitor [5] (Source: Fitbit)

The Fitbit is a small body-worn device which tracks sleep quality and exercise, syncing wirelessly via Bluetooth when within range, automatically uploading data to provide web-based monitoring. As well as linking with their own websites, both products link into Google Health. Nike+ began with an in-shoe sensor, wirelessly linked to an iPod, to monitor, store and upload parameters such as running (or walking) pace, distance covered and calories burned; the product range today also includes a wireless heart monitor and web-based, largely motivational, services.

Such products are presently marketed to people who are already motivated to monitor their own health. However, the trend from initially just monitoring exercise (for fitness geeks, who are already fit), to also embrace sleep and, more recently, weight, is significant. In the future, as such products widen in capability and become more invisible in use, and as Governments, technology providers and health insurers work more closely together, wider monitoring and illness prevention has great potential to reduce treatment costs and improve health.

More advanced home-based patient-monitoring products exist, mainly targeted at hospital authorities, care homes and general practitioners. These include, as an example, the HealthHub from Docobo, which supports measurement of various vital signs, including blood oxygen level (SpO2) and ECG. The HealthHub is essentially a home monitoring solution for long terms conditions, such as chronic heart disease (CHD), chronic obstructive pulmonary disease (COPD) and diabetes, which uploads data to a healthcare provider, enabling active remote monitoring and advice, to support self-management.

Figure 4 The Docobo HealthHub (Source: Docobo)

New and complex products and services, such as Docobo's, face usage barriers arising from issues of medical approval and standardization; clearly there is a need to minimise risks of diagnostic error and mis-treatment. They also face cultural barriers of acceptance, as they imply changes in ways of working within the health service, which some could interpret as a devaluing of their skills. Wellness and remote healthcare is however an area where the social and

health benefits and cost savings are so high that finding ways to manage such barriers should be a priority. The need is not so much for public investment as for the removal of barriers to acceptance and use.

The role of wireless in today's early products and applications has focused on ease-of-use (hence acceptance and usage), reliable upload and monitoring, and, for patients undergoing home-based care, effective two way communications. Looking to the next steps, incorporating sensing capabilities into everyday mobile phones, directly or through wirelessly connected sensors incorporated into personal items of daily life, should accelerate acceptance and take-up.

Beyond this, adding personal, time-varying, contextual information into the mix, gathered automatically via the users phone and other environment-based sensors, has potential to move automated health monitoring from being today's conscious choice of the active few to being a passive usage pattern, acceptable and used by the many. Just as two decades ago, people realised the value of being able to communicate whilst on the move, so, in an era when people are increasingly realising the limitations of medical treatment, if personal health management can be made simple it will be widely used.

Enabling Transport

Major issues in road transport relate to reducing congestion and CO2 emissions; wireless communications have a key role in both. As in healthcare, the potential is huge but the important questions relate to routes to deployment.

Reducing congestion implies a need for comprehensive realtime data and intelligent decision making. Today's increasing availability of GPS-enabled mobile phones provides (i) a self-provided, in-car, sensing mechanism, (ii) a means to communicate the sensed information to a central server and (iii) a way for the driver to receive advice. A one year pilot involving 10,000 drivers, undertaken by UC Berkeley, in partnership with Nokia, Navteq and the California Department of Transport-ation, successfully demonstrated the feasibility and effectiveness of such crowd-sourced sensing and traffic management [8].

Importantly, through data anonymisation and other procedures, it implemented protection of driver privacy [9]. Less sophisticated and less secure solutions are of course already in place, in the form of Live Traffic View on Google Maps. Such developments again indicate the trend to self-provision. However, this does not mean that there is no role for government. Rather, as with healthcare, engagement to work with the telecoms and transport industries to remove barriers and encourage a nationwide, rather than the historically regional approach, could accelerate solutions.

Replacing Transport

Less congestion and improved fuel efficiency are areas where wireless connectivity can contribute to CO2 reduction by enabling intelligent management of vehicles and transportation systems; however, the much larger potential gain lies in the opportunity to replace physical transport of goods and people by the much less energy intensive transport of information bits. Advances in high quality video conferencing have contributed to this trend, further encouraged by constraints on business travel from the economic downturn and by volcanoes impeding air travel in 2010. 3D displays for mobile phones, as well as stereoscopic cameras, are now close to market, if not yet quite commercially viable, whilst life-size holographic displays are also developing. All of these will accelerate this trend in the next few years. Such trends point to significant increases in the volumes of data traffic and, as much of this goes wireless, ceteris paribus, this would drive up energy consumption of mobile networks (though it would still be much less than physical transport). The recent industry drive to reduce the energy consumption of wireless networks by 2-3 orders of magnitude, so-called Green Radio, has emerged in part to address and facilitate this opportunity [10].

Enabling Smart Energy

The challenge of reducing CO2 emissions is sometimes confused with the move from oil to electric vehicles; the electricity required to power the vehicles still of course has a CO2 cost. Nonetheless, after a hesitant start, electric vehicles appear to be imminent and, unless we see a sudden shift to Hydrogen fuel, we will need infrastructure for battery charging, billing and energy management, in which realtime wireless communications will be important.

Figure 5: Electric Cars will Require Demand Management of their Battery Charging (Source: Oxford Brookes University - BMW's academic partner for the MINI E project)

Smart energy implies many things - in the context of electric cars a key need will be to manage demand peaks in charging[5], as many people arrive home from

work, for example. Wireless can help this situation in various ways. Firstly, by monitoring and communicating vehicle location and battery status, the anticipated temporal and geographical charging needs can be synthesized. Combining this with personal contextual data (eg when is a known driver of the car next planning to travel?) can provide an additional level of input to demand planning. Aggregating such information provides some ways to anticipate demand and manage supply. Nonetheless, demand-based pricing will, in all probability, also be needed. Personal data is of course also needed to bill for the electricity, as vehicles will be charged away from home. In all cases, as with earlier examples, security of personally identifiable data is required.

Protecting the Environment, and People

Contextual data on a mobile phone need not be limited to information about the user; as well as location, with the inclusion of a bio/chemical- sensor chip, it could include aspects of his physical environment. Collection, aggregation and real-time analysis of such data across a city, county or country, could deliver highly accurate, timely and localized measurement and monitoring of chemical and biological pollution, providing sensitive and early alerts to environmental threats, and inform their early and proactive management. Such a distributed, crowd-sourced, sensing network could be vastly cheaper than traditional discrete monitoring infrastructures, as well as being more comprehensive.

Tailored bio/chemical-sensors could detect specific bacteria or resultant chemicals in the breath, as a person uses their phone, permitting personal health screening and early detection of illness. Ideally such sensors should possess an easy update mechanism, to allow, for example, the download of a specific virus sensor when a new strain of disease is identified.

Moving from the aggregate to the personal, tailored bio/chemical-sensors could detect specific bacteria or resultant chemicals in the breath, as a person uses their phone, permitting personal health screening and early detection of illness. Ideally such sensors should possess an easy update mechanism, to allow, for example, the download of a specific virus sensor when a new strain of disease is identified. This is still a long way in the future; however, sensor update in the high street shop or in the doctor's surgery could be envisaged, and could provide a powerful new tool in pandemic disease management.

Perversely perhaps, today's Internet users appear largely willing to trade personal privacy in return for perceived added value. Despite widely-publicised concerns over Facebook's privacy policies over the past year, its user base has continued to grow; similarly, Google appears to have weathered some major privacy issues around its launch of Google Buzz.

The global market potential of such phone-based sensors, given the size of the cellphone user base, is clearly huge. The technical requirement for such a capability is low cost, high volume, bio/chemical sensors-on-silicon. Given the UK's strengths in the life sciences and semiconductor industries, this is a field the UK could pioneer. Of course, enabling technology is one thing - issues around commercialization and societal acceptance are another. These are areas where industrial and government collaboration is needed.

Realising Change - People, Industries and Nations

The earlier examples provide 'tasters' of future ways in which wireless may impact industry and society. Many technology enablers already exist, are close or can be envisaged; however realising change involves issues beyond technology, three facets of which we now consider.

Societal Acceptance - Protecting Personal Privacy

The first facet relates to the protection of personally identifiable information. Emerging capabilities of personalised communications hinge around knowledge of sensitive personal information and behaviour. For many in the industry these issues, as noted earlier, have been paramount as such contextually informed services are bring developed. Perversely perhaps, today's Internet

users appear largely willing to trade personal privacy in return for perceived added value. Despite widely-publicised concerns over Facebook's privacy policies over the past year, its user base has continued to grow; similarly, Google appears to have weathered some major privacy issues around its launch of Google Buzz.

Privacy is culturally influenced, differing between countries and cultures, and across social strata [9]. These differences will be important when considering how the third wave of wireless will play out globally in consumer and industry transformation. Whilst many users may be prepared to compromise security in return for a service, some will not. For this reason, public services which require mass adoption – eg health, transport, social care – must not only protect personally identifiable information but also gain the trust of their users to this effect.

Creating Industry Bridges

The second facet relates to the fact that mindsets and assumptions differ enormously between industries. As an example, today content is delivered to mobile phones that traditionally appeared on televisions. This did not come about quickly or easily; in the early days there was suspicion about eating into each other's markets, a lack of trust simply due to lack of relationships and poor appreciation of what was possible and/or inevitable. In this example the rapid growth of public Internet usage was also a factor which pushed the broadcast industry to develop its understanding of telecoms, at both business and technical levels, whilst related initiatives in Asia provided motivation for dialogues. Today the exchange of personnel between industries is much deeper than a decade ago. But all this took time.

As we consider the opportunities to transform and create new growth for the enterprise, healthcare, transport and energy industries, so we need to create opportunities to bridge the cultures, encourage interchange and deepen mutual understanding. Relationships already exist to address immediate market opportunities, but initiatives are needed on multiple levels, particularly when considering future capabilities that are as yet not fully appreciated within some operational units of the telecoms industry.[6]

National Implications

Nations around the world speak about creating a new digital economy. Some have funded significant research initiatives to this end. In the UK these include the 'Digital Economy' hubs, established by the Engineering & Physical Sciences Research Council, and collaborative industrial research, co-funded by the Technology Strategy Board. Few nations have as yet however begun serious industry transition, perhaps in part because the social and cultural changes involved are challenging.

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At this point in time the economic challenges facing the UK are such that such major change is recognized as inevitable. Potentially, if embraced in the right way, this situation could allow more rapid evolution in our industries and public services than would normally be possible, providing an opportunity for the UK to pioneer once again. What is needed to achieve this ? In addition to the issues previously noted, dialogue between industry and government is needed - to identify specific tangible opportunities, to clarify the obstacles to transition and the ways in which they may be removed or circumvented.

Conclusions

The telecoms industry has been transformed by wireless over the past 25 years, a transformation in which the UK has played a leading role. The UK's significant role in the GSM initiative, including the role of government, has been well documented [11]. Early UK analogue cellular pioneers have grown up into global telecom operators. Its leading academic research and culture of innovation continue to play an important role in attracting inward investors and in creating new companies, some of whom have grown into suppliers of key enabling technologies. These strengths are complemented by excellence in semiconductors and life sciences. This rich combination of strengths position the UK well to harness this next wave of wireless to transition our

public services and, en route, build new industrial opportunities. The challenge is not just technology; the stakeholders in the UK, in industry, academia and government, need to work more closely if we are succeed in exploiting our world-class capability to reach its full potential.

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Notes

1 For example, Mobile VCE's research, undertaken by some of the UK leading research Universities, is defined and led by its global industry members Alcatel-Lucent, BBC, BT, Fujitsu, Huawei, NEC, Nokia Siemens Networks, Orange, Samsung, Thales, Toshiba, Turner Broadcasting and Vodafone.
2 The basic feasibility of such services - in terms of harnessing such information and architecting secure mechanisms - has been demonstrated within Mobile VCE's 'Instant Knowledge' research, a programme supported by the Technology Strategy Board
3 The classic example in transportation is the apocryphal intelligent car, requiring six different boxes to support different information and communications systems as it drives through cities from Lands End to John O'Groats
4 The concept of multiple interconnected wireless-enabled personal devices and servers, and supporting mechanisms, formed part of Mobile VCE's 'Vision 2010', developed by its industry members' Vision Group during 1999 [7] and was developed as the 'Personal Distributed Environment' within its Core 2 research programme, which ran from 1999-2003.
5 This is the equivalent of the demand surge arising as millions of people simultaneously switch on their kettles to make a cup of tea in the advertising break during a popular prime time television programme
6 Mobile VCE is initiating cross-industry workshops to help build such understanding, with initial events in the transport, energy and health sectors which will hopefully lead to joint research and commercial collaborations.