

# UK-China Science Bridges: R&D on (B)4G Wireless Mobile Communications (UC4G)

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# I. Background of Science Bridges Projects

- The RCUK wish to enhance linkages with **China, USA, and India** to
  - Accelerate the deployment of research knowledge
  - Deepen and strengthen current research links
  - Enable the acquisition of new skills and **encourage wealth creation through improving the transfer of research and expertise from the research base to businesses and other users** by building science and innovation bridges with world-class universities and high-tech businesses.
- **Science Bridge funding is not available to support additional fundamental research although research necessary to develop knowledge from research into products or services can be included e.g. exploring routes to scale-up.**
- Each country: up to a total value of £4 million over three years.
- Four UK-China, three UK-India and three UK-US collaborations were awarded funding in 2008.

# Science Bridges Awards in 2008

<http://www.rcuk.ac.uk/news/090130.htm>

## ■ **UK-China:**

- UK-China Science Bridge in Sustainable Energy and Built Environment
- **UK-China Science Bridges: R&D on 4G Wireless Mobile Communications (UC4G)**
- Water availability and quality: natural environments, domestic use and food production
- Science Bridges: Bradford-China Programme for Pharmaceutical Sciences and Medical Technology

## ■ **UK-US:**

- Harnessing Materials for Energy
- Stanford-Scotland Photonics Innovation Collaboration
- Innovative Technology for healthcare delivery

## ■ **UK-India:**

- Bioenergy: Technology and Business Solutions for the UK
- Sustainable Indo-UK Agricultural Initiative
- Biopharm 2020: Entrepreneurial Opportunities for Indian/UK Scientists in the Pharmaceutical and Biotechnology Industries

## II. Overview of the UC4G Project

- **Duration:** 3 years (01/08/2009-31/07/2012)
- **Value:** £1M (fEC) or **£907,554** (RC contribution, **reduced from £939,623**)
- **Motivation:** Why (B)4G wireless communications?
  - Digital Economy has been identified as one of the four priority research themes to respond to the challenges facing UK society and the economy.
  - As the key enabler for Digital Economy, ICT plays an indispensable role in modern society.
  - It is extremely important to ensure that the profile and global influence of the UK is sustained in *Wireless Communications*, which is *a*, perhaps *the*, critical element in future global ICT strategy.
  - China is an ambitious and increasingly significant country in the development of wireless technologies, especially in 3G, 4G, and beyond 4G.
    - Huge potential market: the world's largest mobile subscriber population
    - Strong support from the government, industry, and Chinese universities

## i. Aims and Objectives

- To become fully connected with top universities and telecom companies in (B)4G R&D in China.
- To build on the existing substantive collaboration among key UK-China partners and further strengthen and broaden current research links.
- To create, initially, a UK-China panel within Mobile VCE and, ultimately, a **UK-China Joint R&D Centre for Future Wireless Communication Networks**, enabling long-term sustainable collaboration between the UK and China by supporting collaborative research, mutual visits, exchange of researchers, and rapid technology transfer and commercialisation.

## ii. Collaboration Consortium

### ■ China consortium:

Academic Partners (in alphabetic order)	<ol style="list-style-type: none"><li>1) Beijing University of Posts and Telecommunications (BUPT): Prof. Ping Zhang &amp; Prof. Xiaofeng Tao</li><li>2) Huazhong University of Science and Technology (HUST): Prof. Xiaohu Ge</li><li>3) Shandong University (SDU): Prof. Dongfeng Yuan</li><li>4) Shanghai Jiaotong University (SJTU): Prof. Youyun Xu</li><li>5) Southeast University (SEU): Prof. Xiaohu You</li><li>6) Tsinghua University (THU): Prof. Zhisheng Niu &amp; Prof. Zhigang Cao</li><li>7) Xidian University (XDU): Prof. Jiandong Li and Prof. Hailin Zhang</li></ol>
Industrial Partners	<ol style="list-style-type: none"><li>1) Shanghai Research Centre for Wireless Communications (WiCO): <b>Dr. Yang Yang</b></li><li>2) Huawei Technologies Co., Ltd.: Mr Jun Shu</li><li>3) ZTE: Mr Tao Zhang</li><li>4) China Mobile: Mr Chunfeng Cui</li><li>5) Jushri Wireless Technologies, Inc.: Prof. Zhiyong Bu</li><li>6) China Academy of Telecommunication Research (CATR) : Prof. Guili He and Prof. Denian Shi</li></ol>

# Collaboration Consortium (cont.)

## ■ UK consortium:

Academic Partners	<ol style="list-style-type: none"> <li>1) Heriot-Watt University (HWU): Dr Cheng-Xiang Wang</li> <li>2) University of Edinburgh (UoE): Prof. Peter Grant &amp; Dr Harald Haas</li> <li>3) University of Bristol: Prof. Joe McGeehan &amp; Mark Beach</li> <li>4) University of Southampton: Prof. Lajos Hanzo</li> <li>5) University of Bedfordshire: Prof. Jie Zhang</li> <li>6) University College London (UCL): <b>Dr Kin-Fai (Kenneth) Tong</b></li> </ol>
<b>Associate Industrial Partner</b>	<ol style="list-style-type: none"> <li>1) Mobile VCE*: Dr Walter Tuttlebee</li> </ol>
Associate Academic Partners	<ol style="list-style-type: none"> <li>1) King's College London: Prof. Hamid Aghvami</li> <li>2) Univ. of York: Prof. Alister G. Burr</li> <li>3) Univ. of Strathclyde: Dr Ian Glover and Prof. Ivan Andonovic</li> <li>4) University of Surrey: Prof. Zhili Sun &amp; Prof. Rahim Tafazolli</li> </ol>

### \*15 industrial members of Mobile VCE:

Alcatel-Lucent, BBC, BT, Fujitsu, Huawei Technologies, Hutchison 3G, NEC, Nokia Siemens Networks, Nortel, Orange Labs, Samsung, Thales, Toshiba, Turner, Vodafone



### iii. Work Packages and Work Plan

#### ■ Six work packages (WPs):

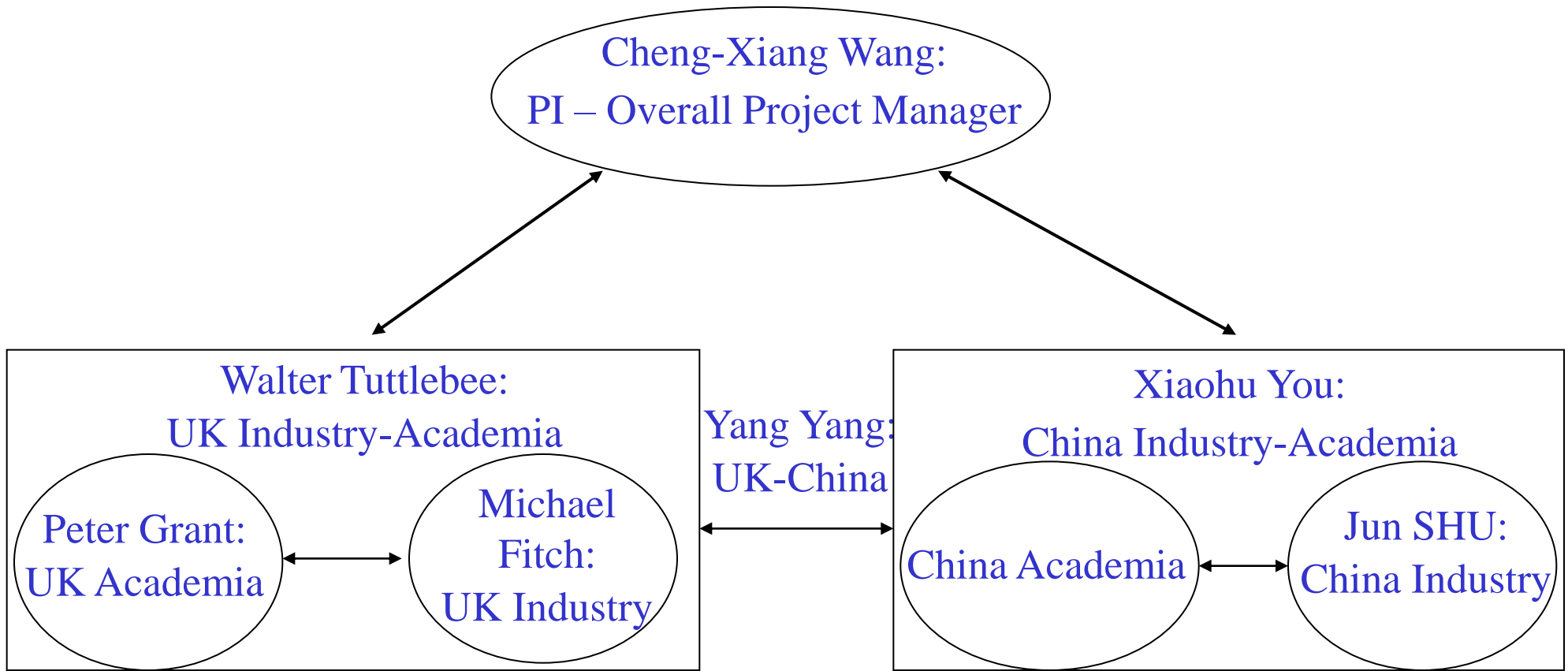
- **WP1:** A delegation of 20 UK researchers visit Chinese partners, including a workshop.
- **WP2:** Exchange of 30 researchers between UK and Chinese universities
- **WP3:** Joint-organisation of two four-day international workshops
- **WP4:** Prototype development and test of (B)4G wireless mobile communication technologies
- **WP5:** Direct commercialisation of mature (B)4G technologies and building trial (B)4G wireless communication networks by industrial partners
- **WP6:** A delegation of 25 Chinese researchers visit UK partners (a three-day project workshop)



## iv. Project Management

- Project Management Committee (7 people):
  - Dr Cheng-Xiang Wang (Heriot-Watt University): PI - overall project manager, with the assistance of the Network Manager (postdoc)
  - Dr Walter Tuttlebee (Mobile VCE): UK industry-academia liaison officer
  - Prof. Peter Grant (University of Edinburgh): UK consortium academic representative
  - **Dr Michael Fitch** (BT): UK consortium industrial representative
  - **Dr Yang Yang (WiCo)**: UK-China liaison officer
  - Prof. Xiaohu You (Southeast University): China consortium academic representative, China consortium industry-academia liaison officer
  - Mr Jun Shu (Huawei Technologies Co., Ltd.): China consortium industrial representative

# Project Management Committee Structure



# Project Management Committee

- The 7 PMC members will meet 3 times (e.g., via video/telephone conference calls) per year to
  - Monitor project progress
  - Evaluate and control risks at each milestone
  - Suggest measures to cope with unexpected deviation
  - Make key decisions
  - Resolve disputes

# III. Project Progress

## ■ WP1:

- **5-26 Apr. 2009:** Cheng-Xiang Wang (CXW) visited China at HWU budget.
- **8 May 2009:** project kick-off meeting held at Heriot-Watt Univ.
- **20 May 2009:** Chinese partners applied leverage funding from MOST (**not successful**).
- **29 June 2009:** 1<sup>st</sup> PMC teleconference meeting held to comment on workshop slides
- **6 July 2009:** Network Manager (Postdoctoral RA) Dr Xuemin Hong appointed
- **25 July-9 Aug. 2009:** WP1--22 UK delegation members visited China
- **4-6 Aug. 2009:** A joint-workshop (and a PMC meeting) held at Tsinghua University
- **Sept. 2009:** project website established <http://uc4g.eps.hw.ac.uk/>
- **1 Dec. 2009:** WP1 report published
- **April/May 2010:** Signatures of the agreement from all the partners were received and the full agreement was sent out to all the partners.

# Project Progress (Cont'd)

## ■ WP2:

- **1 Feb. 2010:** WP2 First Call for Proposal (application deadline: **5 March 2010**)
- **31 Mar. 2010:** 2<sup>nd</sup> PMC teleconference meeting held to make decisions on the first round WP2 UK-China Visiting Fellowship awards.
- **14 Apr. 2010:** First round of WP2 UK-China Visiting Fellowship awards announced
- **11 May 2010:** WP2 second Call for Proposal (application deadline: **31 May 2010**)
- **5 July 2010:** 3<sup>rd</sup> PMC teleconference meeting held to make decisions on the first round WP2 UK-China Visiting Fellowship awards.
- **8 July 2010:** A workshop held at UCL
- **Late July 2010:** WP2 third Call for Proposal (application deadline: **30 Sept. 2010**)

# Project Progress (Cont'd)

- **WP3:**
  - **23-24 Aug. 2010:** 1<sup>st</sup> WP3 joint-workshop to be held in Beijing
  - **12-13 Sept. 2010:** 2<sup>nd</sup> WP3 joint-workshop to be held in Shanghai
- **WP4:**
  - Initial investigation underway
- **EPSRC Mid-term Evaluation (deadline: 23 September 2010):**
  - 4-page report+2-page appendix
  - 3-minute video highlighting the achievements



# Work Package 1: Visit to China

## ■ **Objective:**

- To promote knowledge exchange in (B)4G among Chinese and UK consortium members and further strengthen and broaden current collaboration links.

## ■ **Deliverables (D1):**

- a project website for efficient dissemination and sharing of information;
- travel itinerary of the 16-day China trip, schedules and presentation slides of the workshop;
- a summary report addressing collaboration opportunities and areas among UK and Chinese partners, and experience and lessons of Beijing Olympics 2008 in choosing advanced wireless technologies;
- a full collaboration agreement (**required by the EPSRC**) between all UK and Chinese consortium members.

## ■ **Milestone (M1):**

- UK and Chinese partners get to know each other and a collaboration agreement is in place.

# Overview of the Mission to China in Summer 2009

- From 27 July to 7 Aug. 2009, a UK delegation with 22 members, led by Dr Cheng-Xiang Wang from HWU and Dr Yang Yang from UCL, visited 12 Chinese partners (7 universities and 5 companies) in 6 cities (Shanghai, Nanjing, Wuhan, Xi'an, Jian, Beijing).
- A welcome reception was hosted by British Consulate General Shanghai on 27 July 2009.
- A two-and-a-half day workshop was held at Tsinghua University, Beijing, from 4 to 6 Aug. 2009, with about 70 attendees.

# Sponsors and Supporters

## ■ Sponsors

- 19 UK delegation members were sponsored by the Research Councils UK
- 3 UK delegation members were sponsored by Digital Communication Knowledge Transfer Network (DC-KTN)

## ■ Supporters

- RCUK China Office
- British Embassy in Beijing
- British Consulate General Shanghai
- Ministry of Science and Technology (MOST) of China
- National Natural Science Foundation of China (NSFC)
- Science & Technology Commission of Shanghai Municipality
- All of our 13 Chinese partners

# Key Findings

- Compared with China, there is a significant funding deficiency in the UK in Wireless Communications area. The Chinese central government has revealed a plan to invest 70 billion RMB (1 GBP  $\approx$  11 RMB) on new generation mobile wireless broadband communication networks in the period from 2008 to 2020.
- All Chinese academic partners have not only conducted good-quality research but also heavily involved in prototype/testbed developments in (B)4G systems.
- Compared to China, the strength of the UK comes from the very productive research system. The unique linkage between the academia and industry, such as that created by the Mobile VCE, continues to offer very high returns for R&D investment.

# Impacts and Outcomes

- **The UC4G project has been further promoted.**
  - The Chinese consortium members have got better understandings about the UC4G project.
  - All the consortium members have become familiar with each other.
  - Substantial attention has been attracted at the government level.
    - British Embassy, MOST, and NSFC
  - Wider awareness of the UC4G project has been raised.
    - National Physical Laboratory (UK)
    - Swansea University
    - Nokia Siemens Networks (Beijing)
    - Peking University
    - Zhejiang University

## Impacts and Outcomes (cont.)

- **Future plans for the UC4G project have been openly discussed.**
  - Complementary strengths in (B)4G R&D activities were identified.
  - Topics for future collaboration in WP2 and beyond were openly discussed.
  - It was agreed that WP2 can serve as the starting point of peer-to-peer collaborations and pave the way for further (joint) funding applications from e.g., EPSRC and TSB in the UK, MOST and NSFC in China, EU, and industries.
  - How to enhance the impact of the project was discussed, such as taking the opportunity of Expo Shanghai 2010 to organise the first workshop for WP3 and showcase the UC4G project.
  - Chinese partners, such as WiCO, have expressed their willingness to allow the UK partners to use their advanced testbeds/equipments, especially for WP4 (prototype development).

# Identified Benefits to Project Partners

## ■ **UK academia**

- Access to a huge intellectual bank to empower quality research
- Access to the state-of-the-art hardware resources for rapid proof-of-concepts

## ■ **China academia**

- Access to world-class 4G expertise to drive research excellence
- Raise global awareness and international influence

## ■ **UK industry**

- Cost-effective strategic research
- Gateway to the huge consumer market in China

## ■ **China industry**

- Cost-effective strategic research
- Gateway to the western market

## WP2: Staff Exchange (01/11/2009—30/01/2011, 15 months)

### ■ **Objective:**

- To further intensify the existing R&D links, explore new links, and ensure high-quality, long-term, and sustainable research collaborations between the UK and China.

### ■ **Deliverables (D2):**

- formation of UK-China collaborating partnerships and short-term visiting fellowship (up to 3 months) opportunities for UK & Chinese researchers;
- 30 reports detailing key (B)4G technologies to be possibly prototyped, tested, and commercialised;
- joint publications, posters, joint project applications, IPR applications, and (B)4G standard proposals;
- creation of a UK-China panel within Mobile VCE.

### ■ **Milestone (M2):**

- Full interaction of UK and Chinese academic consortium members.



## Overview of Work Package 2

- WP2 is designed to promote full interactions of UK and Chinese consortium members by exchanging 30 researchers, preferably academic staff, and forming UK-China collaboration partnerships.
- The 30 UK-China Visiting Fellowships will be awarded to eligible researchers to visit one or multiple UC4G consortium members in the other country for up to 3 months.
- The Visiting Fellowships aim to provide seed money for collaborative research that will
  - Forge long-term sustainable collaboration
  - Promote knowledge transfer from academia to industry
  - Commercialise some of the research through developing industrial links and securing industry and other funding.

# Assessment Criteria of Work Package 2 Applications

- The Applicant and Host Researcher(s):
  - Current standing and track record of the applicant and the host researcher(s) in the area of the proposed research;
- The proposed research:
  - Novelty and quality;
  - Impact, mutual benefits, and planned outcomes/deliverables;
  - Industrial interests/supports and prototype/commercial potentials;
- The Research Environment:
  - Ability of the applicant, hosting researcher(s), and their teams to deliver the proposed research;
  - Support from the applicant's head of institution (a signed supporting letter required), indicating consent for the applicant to spend time away from their institution;
  - Support from the host researcher's head of institution (a signed supporting letter required), indicating consent to the visit and the period;
- Planning of the proposed visit and time commitment of the host researcher(s) during the visit;
- Balance of different research topics in the (B)4G area;
- Balance of the Visiting Fellowships allocated to eligible UC4G partners.

# Estimated Time Scales

- The 30 visiting fellowships will be awarded in three separate rounds.
- Application deadlines for these three rounds are 5 March, 31 May, and **30 September 2010**.
- The PMC, together with the Industrial Steering Groups, will aim to assess the applications and announce the UK-China Visiting Fellowship Awards within 1 month after the application deadlines.
- All the proposed visits should aim to start before 1 Feb. 2011 and end before 30 April 2011.

# Overview of First Round Applications

- The first round UK-China Visiting Fellowship Call for Proposal received 10 applications
  - 5 applications received unconditional awards.
  - 2 applications received conditional awards (1 withdraw).
  - 3 applications were deferred to the second round for reconsideration after major revisions.
- 7 Chinese institutions and 5 UK institutions were involved.
- 7 applications proposed research topics in the area of Radio Access, 2 in the area of Networking, and 1 in the area of Antennas and Propagation.

# Successful Applications in the First Round

Ref.	Applicant	From	To	Project Title
<b>R1.01</b>	Prof. Alister Burr	York (UK)	SJTU	Physical layer network coding for 4G and beyond
<b>R1.02</b>	Yu Chen	UCL (UK)	WiCO	QoS-Guarantee Algorithms for Multi-hop Wireless Mesh Networks
<b>R1.03</b>	Dr. Xuemin Hong	HWU (UK)	WiCO & BUPT	Feasibility Study on a UK-China Open Access (B)4G Wireless Mobile Communication Testbed
<b>R1.04</b>	Dr. Wei Chen	THU (China)	SAMP	Physical Layer Network Coding: From Theory to Practice
<b>R1.05</b>	Assoc. Prof. Xiaohu Ge	HUST (China)	HWU	Energy Efficient Technologies for Cooperative MIMO Mobile Communication Systems Based on Interference Coordination
<b>R1.08</b>	Dr Hongjun Tang	SEU (China)	UCL	Compact Three-dimensional Polarization Antennas for 4G Mobile Communication Systems
<b>R1.09</b>	Assoc. Prof. Meixia Tao	SJTU (China)	SAMP & UCL	Multi-Cell MIMO Precoding for Next-Generation Cellular Networks ( <b>withdraw</b> )

# Overview of Second Round Applications

- The second round UK-China Visiting Fellowship Call for Proposal received 10 applications
  - 1 application received the unconditional award.
  - 5 applications received conditional awards.
  - 4 applications were deferred to the third round for reconsideration after major revisions.
- 4 Chinese institutions and 5 UK institutions were involved.
- 8 applications proposed research topics in the area of Radio Access, 1 in the area of Networking, and 1 in the area of Antennas and Propagation.

# Successful Applications in the Second Round (to be confirmed)

Ref.	Applicant	From	To	Project Title
<b>R2.01</b>	Dr. Pei-Jung Chung	UoE (UK)	SEU	Robust Relay Network Beamforming: A Probabilistic Constrained Optimization Approach
<b>R2.02</b>	Dr. Hui Song	Bedfordshire (UK)	SDU & BUPT	Coordinated Radio Resource Management (CoRRM) for LTE-Advanced
<b>R2.03</b>	Dr. Cheng-Xiang Wang	HWU (UK)	SEU & SDU	Realistic Cooperative MIMO Channel Models for 4G and Beyond
<b>R2.06</b>	Assoc. Prof. Qimei Cui	BUPT (China)	UoE	Network coding in future wireless communication
<b>R2.07</b>	Assoc. Prof. Wei Liu	XDU (China)	Southampton	Block Diagonalization Based Multiuser MIMO Aided Downlink Relaying
<b>R2.08</b>	Prof. Xiaofeng Tao	BUPT (China)	UoE	Green Multi-users CoMP Transmission Technique

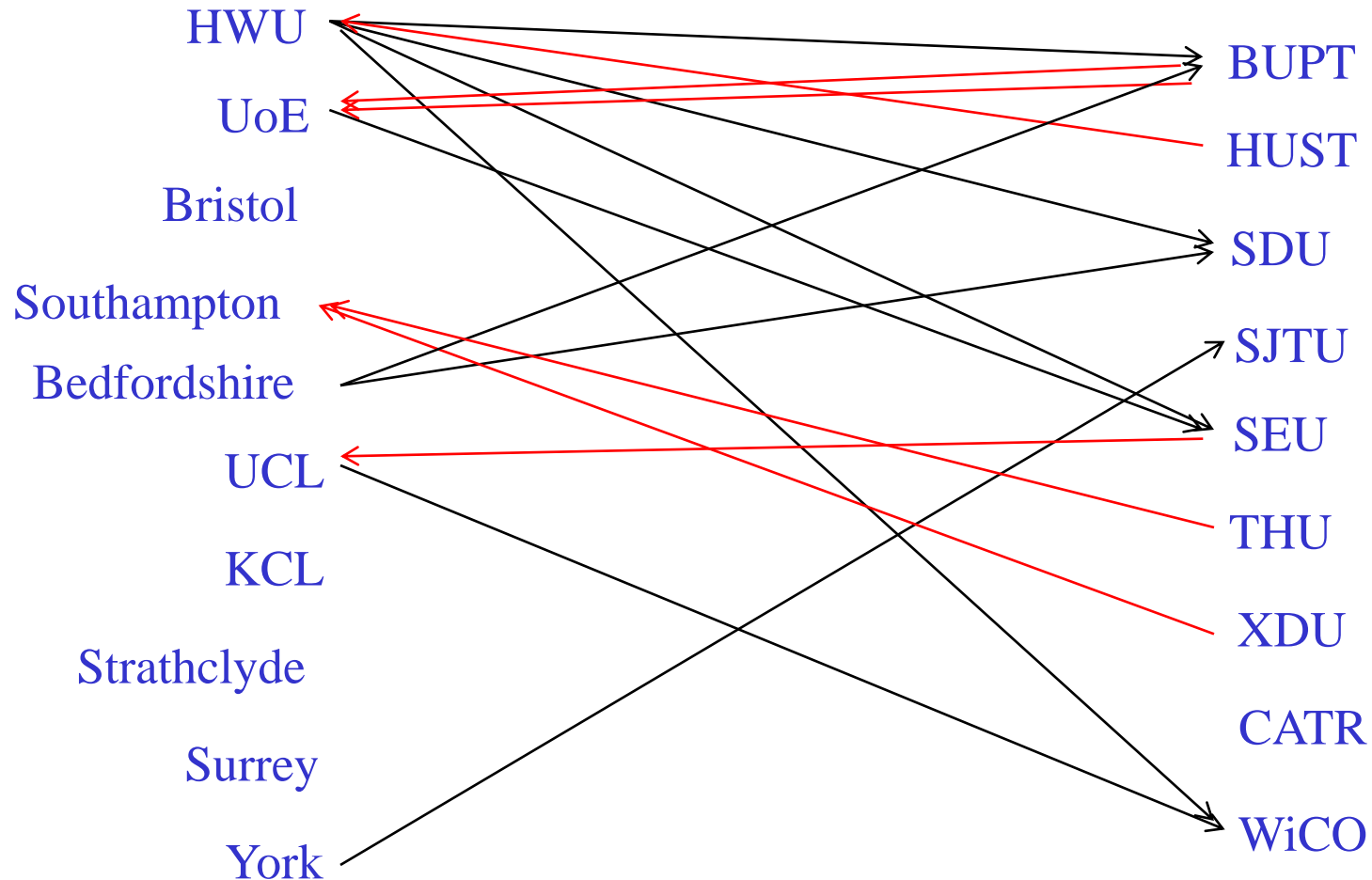
# Overview of Awarded Fellowships (To be Updated)

	Host	Out	NO. Links
HWU	1	2	5
Edinburgh	2	1	4
<b>Bristol</b>	<b>0</b>	<b>0</b>	<b>0</b>
Southampton	2	0	2
Bedfordshire	0	1	1
UCL	1	1	2
<b>KCL</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Strathclyde</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Surrey</b>	<b>0</b>	<b>0</b>	<b>0</b>
York	0	1	1

	Host	Out	NO. Links
BUPT	2	2	4
HUST	0	1	1
SDU	2	0	2
SEU	2	1	3
SJTU	1	0	1
THU	0	1	1
XDU	0	1	1
<b>CATR</b>	<b>0</b>	<b>0</b>	<b>0</b>
WiCO	2	0	2



# Illustration of Funded Collaboration Links



## WP3: International Workshops (01/02/2009—31/07/2011, 18 months)

### ■ **Objective:**

- To disseminate the joint findings, share knowledge among wider community, involve industry leaders with invited talks to shape the R&D focus, and explore new business models.

### ■ **Deliverables (D3):**

- two workshops and proceedings;
- joint publications and posters in workshops.

### ■ **Milestone (M3):**

- Raise wider awareness of UK-China collaboration activities and publicise the outcomes.

### ■ **Planned WP3 activities in 2010 :**

- 23-24 Aug. 2010: a UK-China joint workshop at BUPT in Beijing
- 12-13 Sept. 2010: a UK-China joint workshop in Shanghai

# WP4: Prototype Development

(01/08/2010—30/04/2012, 21 months)

## ■ **Objective:**

- To develop prototypes and test/verify findings using wireless testbeds and to facilitate proof of concept, technology transfer, and commercialisation.

## ■ **Deliverables (D4):**

- (B)4G wireless communication technology prototype;
- IPR applications;
- reports and posters regarding the verification results of developed (B)4G technologies using the wireless testbeds.

## ■ **Milestone (M4):**

- Prototype development and verification of (B)4G wireless technologies.

# Preparatory WP4 activities

- Dr. Xuemin Hong's visits to SEU and WiCO in April/May 2010, and BUPT in Sept./Oct. 2010.
  - Investigate the feasibility of setting up a joint UK-China testbed
- Dr. Cheng-Xiang Wang, Dr Xuemin Hong, and 2 HWU PhD students visited R&S (UK) and Surrey University in June 2010.
  - 4 related MSc projects at HWU
- London UCL workshop
  - Seek industrial opinions and collect suggestions from other partners

# WP5: Commercialisation of Mature (B)4G Technologies

(01/02/2010—31/07/2012, 18 months)

- **Objective:**

- To commercialise mature (B)4G wireless technologies to real products and impact positively the UK and Chinese economy.

- **Deliverables (D5):**

- new (B)4G wireless technology products.

# WP6: Visit to the UK and Final Project Workshop (01/05/2012—31/07/2012, 3 months)

## ■ **Objective:**

- To share main findings and collaboration outcomes, and identify new collaboration opportunities and follow-up activities with the wider community in the UK and China.

## ■ **Deliverables (D6):**

- a final project report summarising the collaboration outcomes and identifying follow-up activities;
- establishment of a **UK-China Joint R&D Centre for Future Wireless Communication Networks**.

## ■ **Milestone (M5):**

- New products of 4G wireless communication technologies and creation of a UK-China R&D Centre in 4G wireless mobile communications.

# Summary

- **WP1:**
  - UK and China have complementary strengths in the (B)4G R&D area, making a joint collaboration initiative necessary and extremely valuable.
  - UK partners can benefit from such collaborations by sharing huge funding from the Chinese government/industry and getting access to the state-of-the-art infrastructure.
  - Chinese partners can benefit from such collaborations by improving the effectiveness of their research investments and raise global influences.
- **WP2:** Full interactions of UK and Chinese (academic) consortium members are underway.
- **WP3:** Workshops are being organised to generate wider impacts and facilitate interactions between the UC4G partnership with the wider (B)4G community.
- **WP4:** Early investigations are underway to pave the way for building joint wireless testbeds.

# Scottish Government Reception in Shanghai



Left to right:  
Dr. Cheng-Xiang Wang, Professor Andy Walker,  
First Minister Alex Salmond and Zhongyi Wang



Left to right:  
Dr. Cheng-Xiang Wang, Professor Andy Walker,  
Education Secretary Fiona Hyslop



# WP1 Snapshots

WiCO, 27 July 2009



Jushri, 27 July 2009



# WP1 Snapshots

Reception hosted by British General-  
Consulate Shanghai, 27 July 2009



Huawei, 28 July 2009



# WP1 Snapshots

Shanghai Jiao Tong University, 28 July 2009

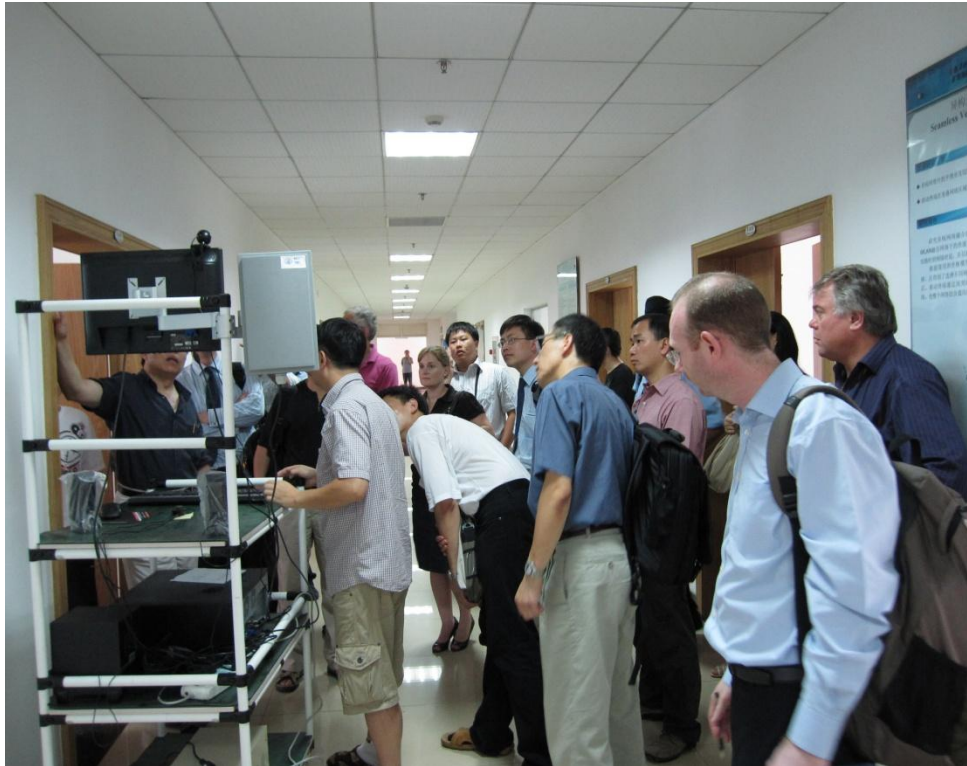


Southeast University, 29 July 2009



# WP1 Snapshots

HUST, 30 July 2009



Xidian University, 31 July 2009



# WP1 Snapshots

Shandong Univ., 3 Aug. 2009



Tsinghua Univ., 4 Aug. 2009



# WP1 Snapshots

Tsinghua Workshop, 4-6 Aug. 2009



# WP1 Snapshots

BUPT, 6 Aug. 2009



China Mobile., 6 Aug. 2009



# WP1 Snapshots

CTTL-CATR., 7 Aug.

