



OFC/NFOEC2007

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Optical Fiber Communications In Mainland China –

Activities and visions of carriers,
equipment vendors and academia

Chongcheng Fan

Tsinghua University (Retired)

Beijing, China

deefcc@mail.tsinghua.edu.cn

Acknowledgement

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China Mobile: T Liu, YC Guo

China Telecom: LP Wei, CL Zhang, JJ Li, JF Xu

China Unicom: WC Shen

– **Fiberhome:** Q Mao, JL Wang

– **Huawei:** CT Cai, W Zhang, AL Shen

– **ZTE:** JY Wang, T Chang

– **BUPT:** JT Lin, J Wu

– **SJTU:** WS Hu

– **Colleagues/students:** HW Chen, MH Chen, YT Dai, HD Huang, CZ Peng, JD Peng, SH Wang, JP Wu, SZ Xie, XP Zheng, L Zhang, W Zhang,

Y Du, XL Hu, N Hua, F Liu, J Sun, K Wang, T Wang, Y Wang, SG Yang...

Outline

- **General Picture and Policy**
- OFC Industry Chain
 - Telecom Carriers
 - System Vendors
- Optical Network Technologies
 - Broadband Access and Applications
 - IP/Packet-based Transport Network
- Academic Research Activities
- Concluding Remarks

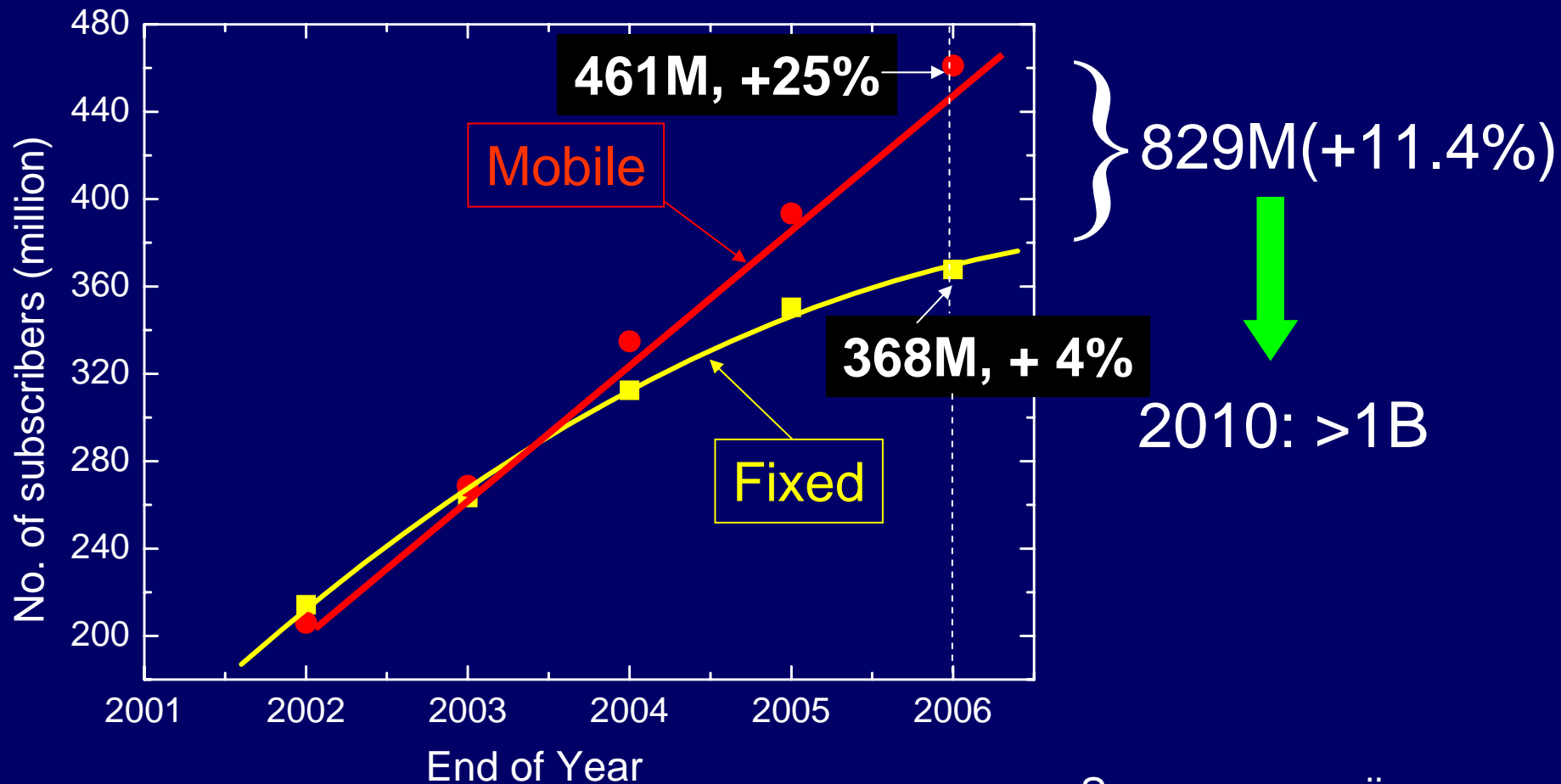
Telecom Industry in M. China

- Oct '06 vs. Oct '01 (when China joined WTO)
 - Fixed phone subscribers x2
 - Mobile phone subscribers x3 } 1/4 world total
 - Internet users x4 -- 1/10 world total
- Currently
 - **Biggest** network and **largest no.** of subscribers
 - No. of Internet users **second largest** worldwide
 - All the 4 major carriers went IPO overseas
 - Products of **Huawei**, **ZTE** and **FiberHome** etc. go to 100+ countries
 - R&D in some areas **world-class**

Source: YP Jiang, Vice Minister MII, Dec 11, 2006; www.tele.com

No. of Phone Subscribers

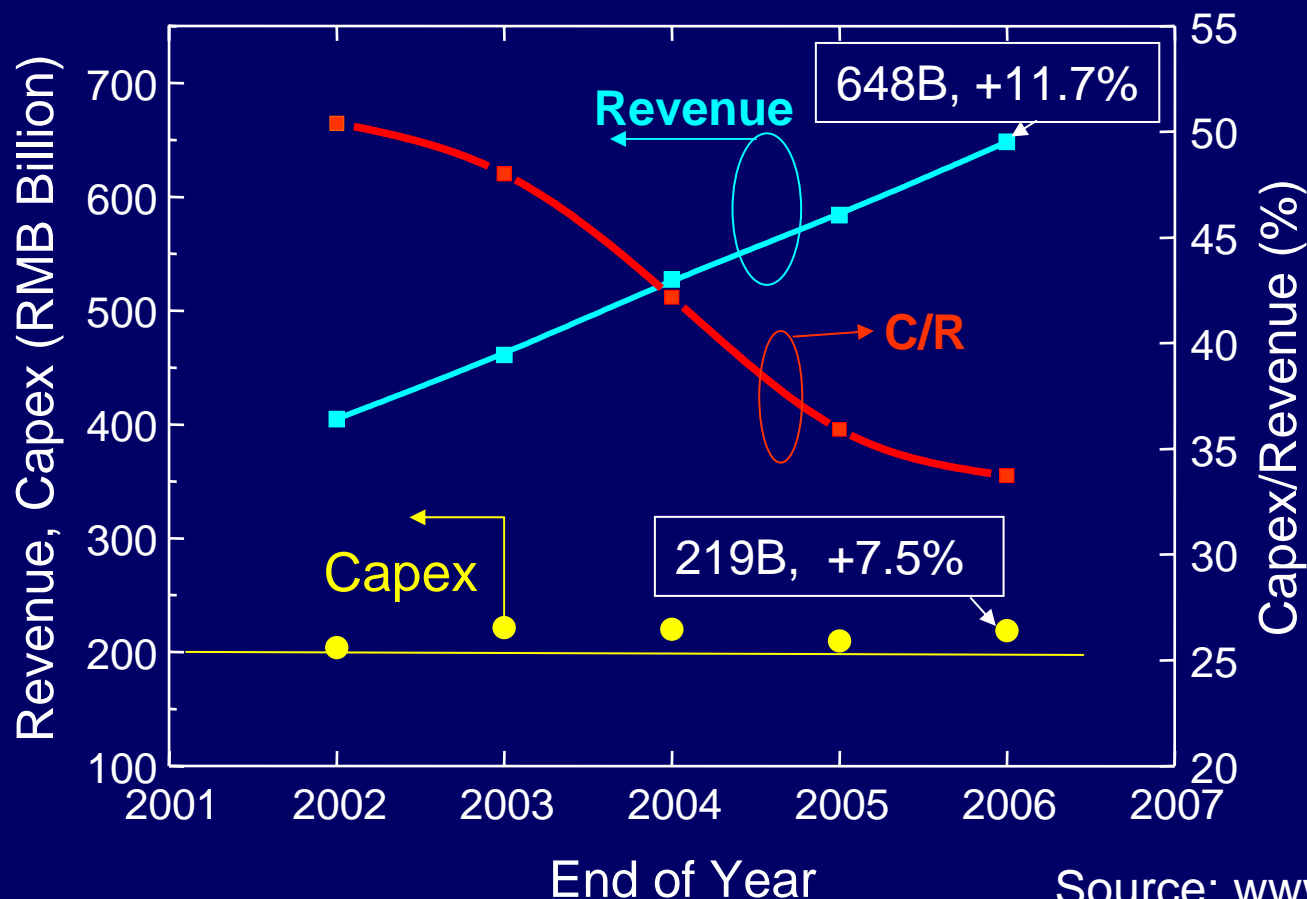
- Penetration: Mobile 35.3%, Fixed 28.1%



Source: www.mii.gov.cn

Telecom Carriers: Revenue & Capex

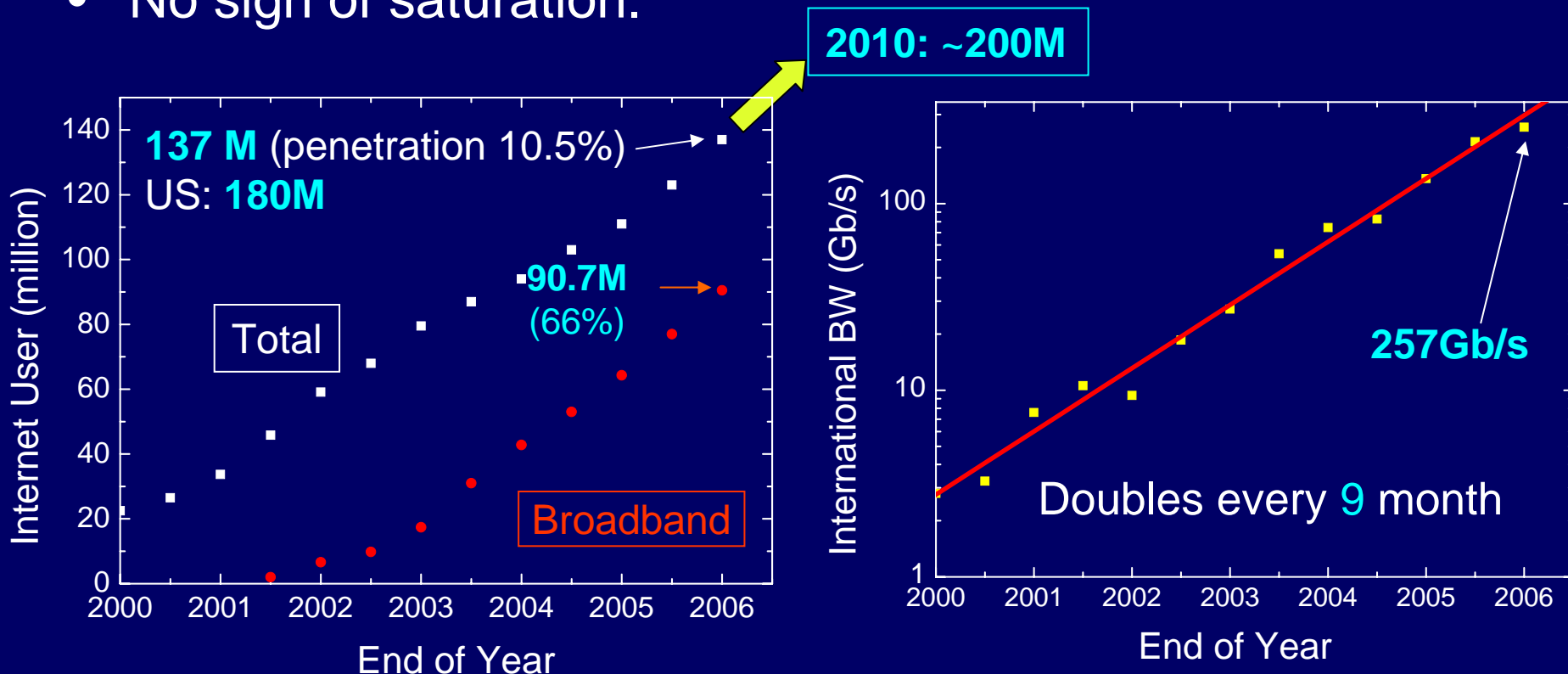
- Linear increase in Revenue (~ +60B/yr)
- Capex consistently \geq RMB 200B
 - 2006: Fixed Capex: -6.3%; Mobile Capex: +19.6%
- Decreasing Capex/Revenue, but still $>1/3$



Source: www.mii.gov.cn

Internet: Evolving into Broadband

- Penetration $\sim 10\%$, while \ll developed countries ($>60\sim 65\%$).
- Broadband user $\sim 2/3$
- Exponential growth in int'l connection bandwidth.
- No sign of saturation.

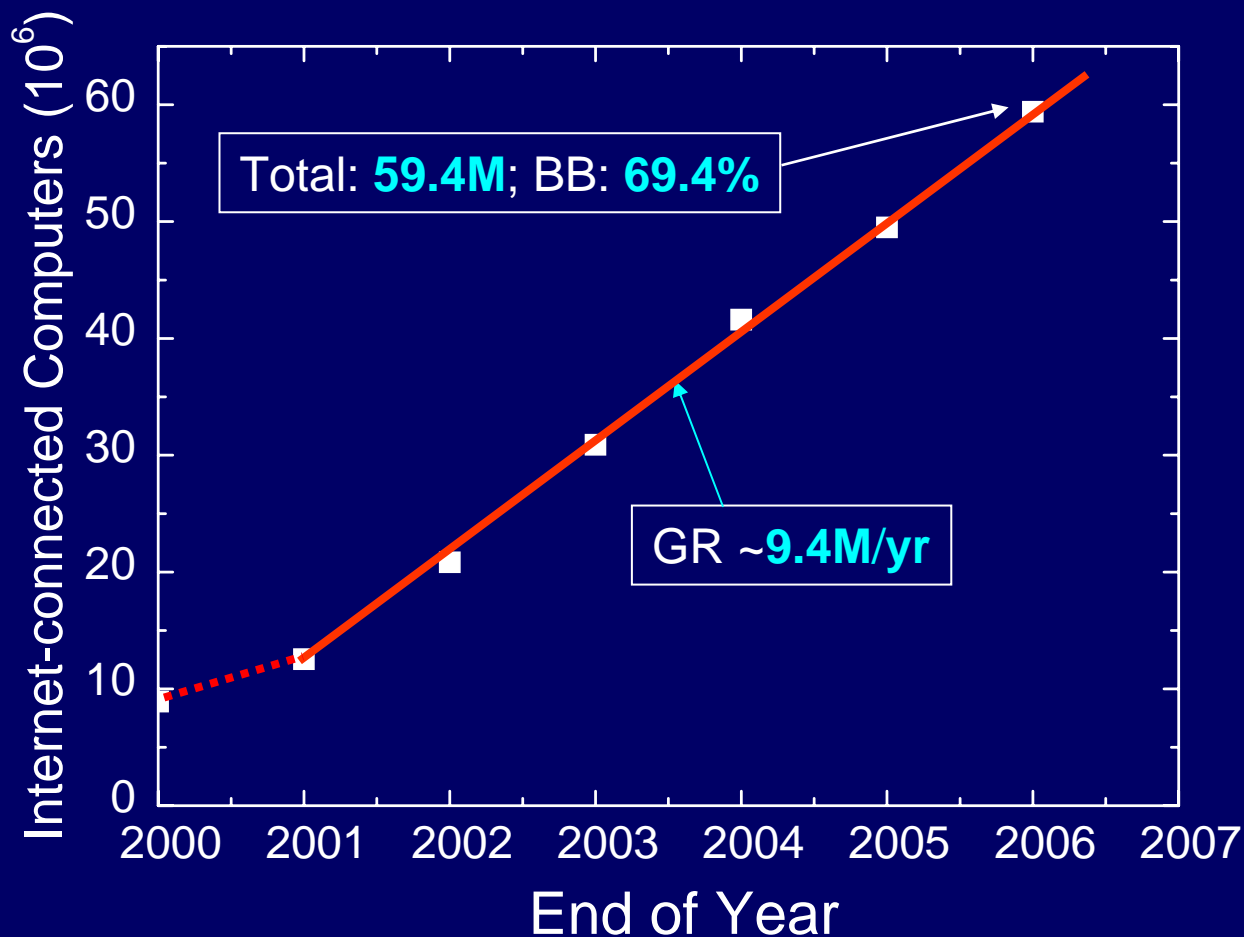


* Broadband users : DSL, cable modem, etc.

Source: CNNIC Report, Jan '07

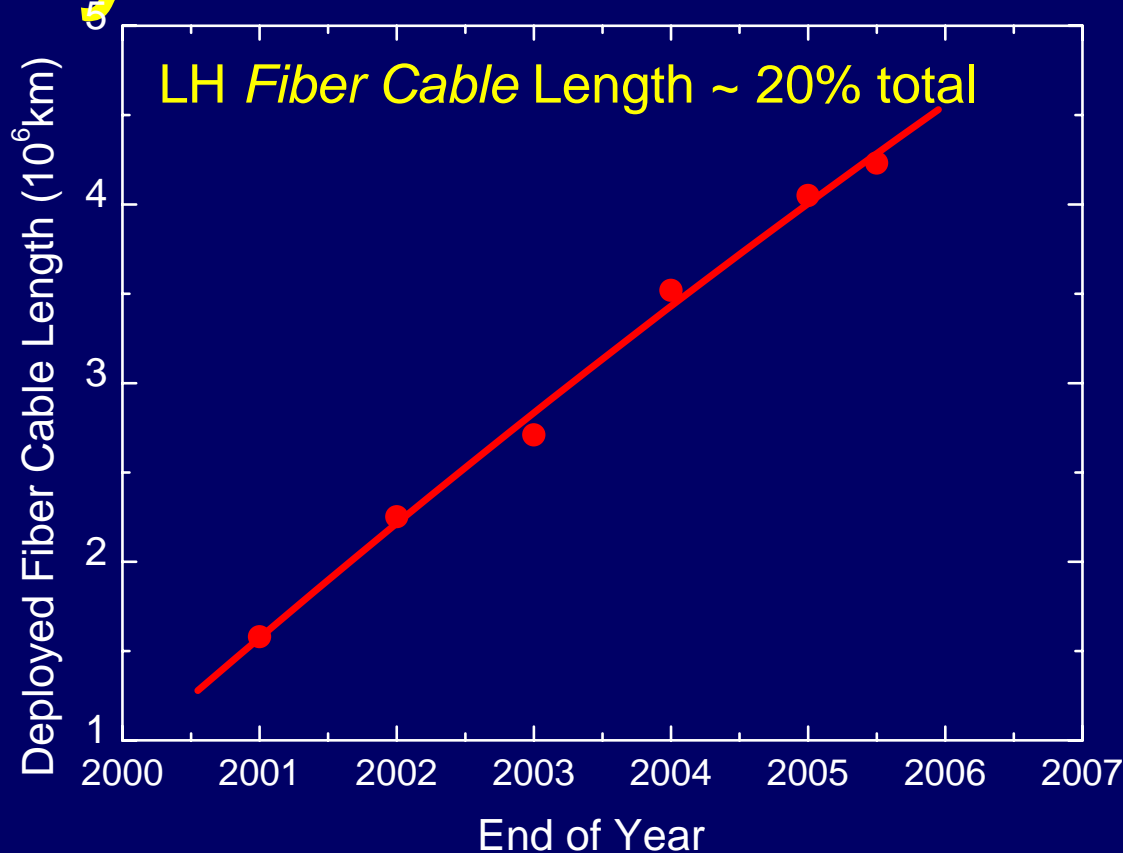
Internet Access: Computers Connected '06

- Broadband connection ~70%.



Source: CNNIC Report, Jan '07

Deployed *Fiber Cable* Length



- Deployed *fiber length* in 2006: 13Mkm (US: 22Mkm)
 - Accumulated deployed *fiber length* ('06): ~89Mkm

EB Desurvire, JLT, 24, 4697, '06

Source: www.mii.gov.cn, www.coema.org.cn

State Policies & Evolution Trends

Mode of Economic Growth → Innovative

Telecom Industry → Information Service Industry

Carriers → Converged Info Service *Players*

Equipment Vendors → Converged System &
Service Solution *Providers*

National IT Strategy 2006-2020

THE STATE COUNCIL

- Info service for agriculture, villages and farmers
 - Bridging the “digital gap”
 - “Tele-Service to Every Village” Project
- Converged Information Infrastructure
 - Promotion of network convergence
 - Triple-play (service, network and terminal)
 - Broadband Access
- Friendly IT environment
 - User-friendly, Affordable and Benefiting everyone.

Source: <http://news.xinhuanet.com>

Info Industry: '06-'10 & Towards '20

MINISTRY OF INFORMATION INDUSTRY

- Key Projects

- Next generation optical networks

- ASON
- FTTx
- OXC w/ high capacity and multiple granularity

- Broadband mobile wireless telecom

- Broadband wireless access
- Enhanced 3G
- Beyond 3G

- Agricultural information platforms

- Production, management and decision-making
- Trading, distribution services...

Source: <http://www.cnii.com.cn/20060808/ca369603.htm>,
MII 11th Five-Year Plan ('06-'10) and towards '20

“Tele-Service to Every Village” Project

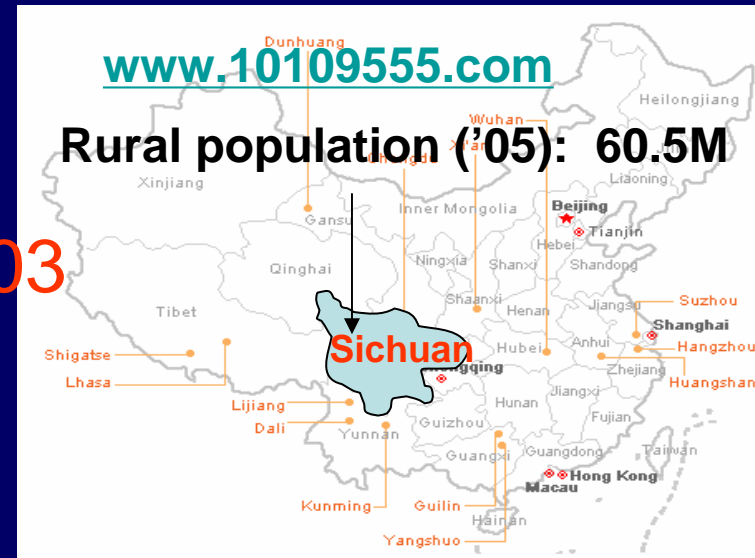
- Critical Concern of the Government
 - Rural population: 800M~900M
- In-time and highly localized information for farmers’ benefit: higher income / lower loss:
 - Agricultural weather messages.
 - Where to buy/sell seeds, fertilizers, produce...
 - Techniques to grow new and/or improve produce.
 - Prevention and management of pests, livestock diseases, natural disasters...
 - Managing needs for workforce.
 - Legal and regulatory services and advices.

“Tele-Service to Every Village” Project

- As of End '06
 - 98.9% of all *administrative* villages connected by phone service; 100% connection expected '07.
 - 100% *geographical* village phone service expected 2010.
 - All carriers met assignment ahead of schedule.
- 6000+ agricultural **websites nationwide**
 - **Voice+data Info Platform** based on integration of Internet, cellphone, short-message and manual calling center.
- **Features:**
 - Affordable
 - Instant and interactive
 - “Grandma and minorities usable”

Case Study: *Tianfu* Agriculture Network

- Sichuan Province
 - Major farmer produce supplier
- Built by **China Unicom** since '03
 - Supported by the State Electronic Business Platform Project with **7.5M RMB** funding
 - Up to '05, **1000+** info stations established, and **>300M** messages issued.
 - Recipient of **UNESCO** “World Information Summit Award”



Value of offering a *general-public-oriented* product for the *poverty* people in *developing* countries with a *successful* business model.

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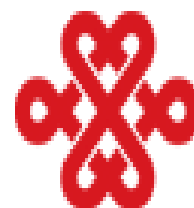
Telecom Carriers

CM



中国移动通信
CHINA MOBILE

Mobile Information Specialist



China
unicom 中国联通

CU

CT



中国电信
CHINA TELECOM

Connecting the World



CNC
中国网通

CN

CR



中国铁通
CHINA RAILCOM



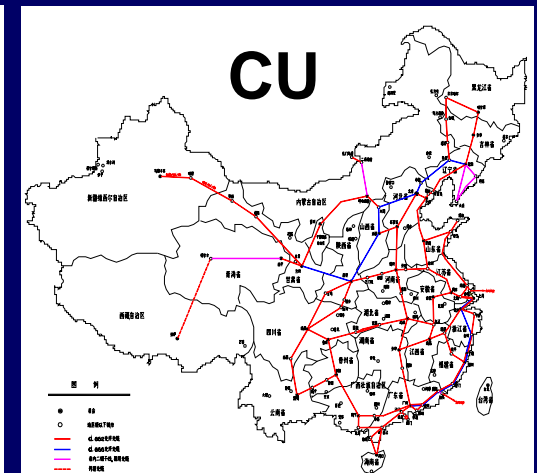
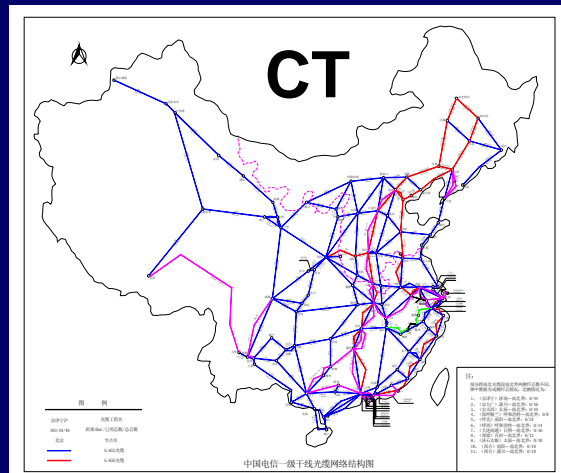
中国卫通
CHINA SATCOM

CS

Inter-Provincial Backbones '06

Mainstream Capacity/fiber: 40 x 10/2.5 Gb/s

- China Mobile: Fiber Cable Length 45,000km (2006)
- China Telecom:
 - Deployed fiber >2Mkm
 - Many 80X10Gb/s systems operate w/ full capacity.
 - 80x40Gb/s WDM trial system Shanghai - Hangzhou.
- China Unicom: Fiber Cable Length 38,000km (Apr'04)



Intra-Provincial Backbone

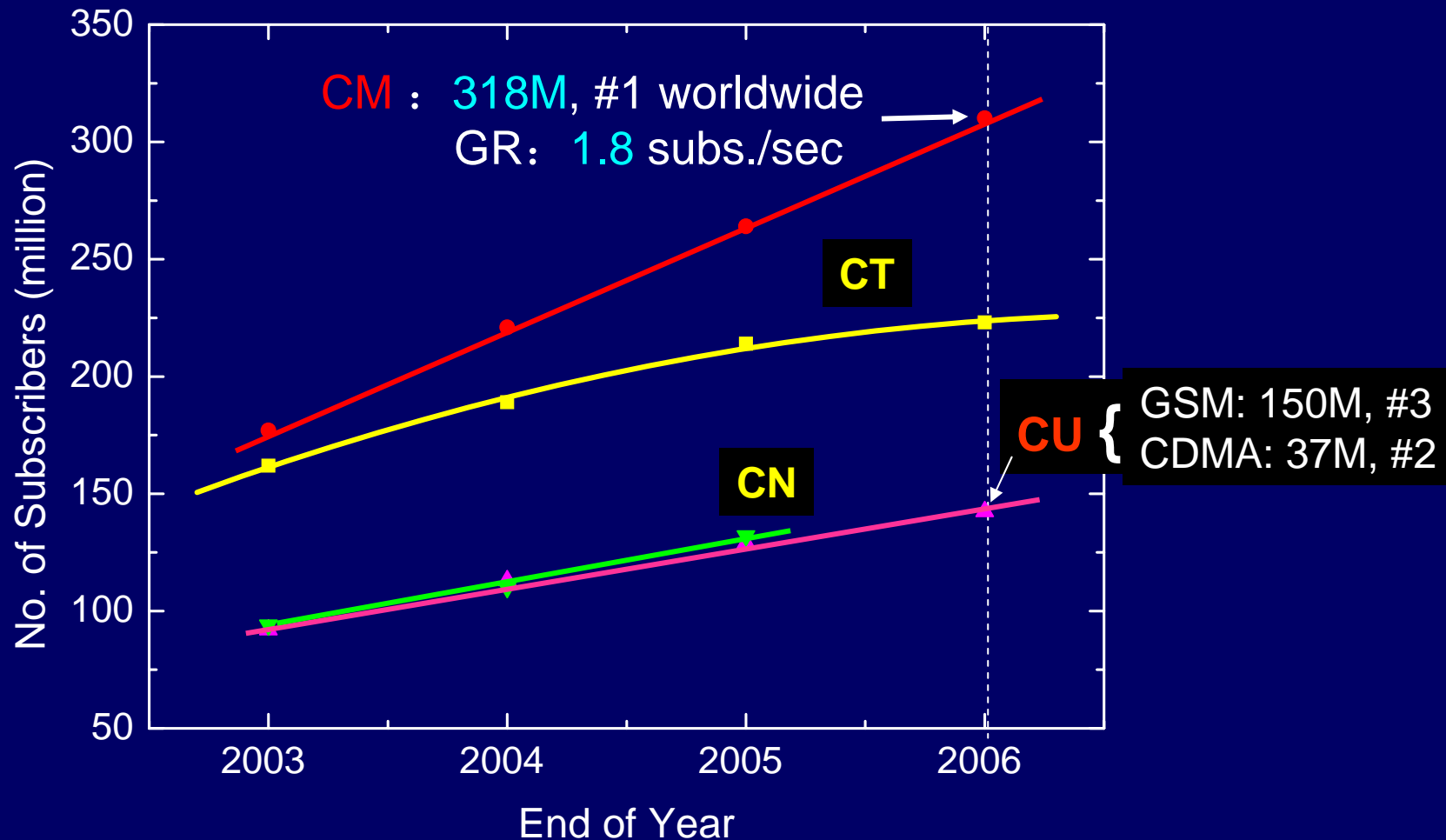
The 1st DWDM Trunk with 160x10Gb/s Max Capacity



- BB IP services of CT's CN2(ChinaNet 2) network.
- SuperWDM[®] technology of Huawei.

Subscriber Breakdown By Carriers

- **CM**: largest no. worldwide; linear growth.
- **CT**: approaching saturation.



Revenue / Profit / VAS Income Breakdown 1H '06

1H 2006	China Mobile	China Telecom	China Unicom	China Netcom
Revenue Total: RMB 310.1B	44.0%	27.1%	15.0%	13.9%
Net Profit Total: RMB 51.7B	58.4%	22.4%	5.4%	13.7%
VAS Income Total: 59.2B	52.2%	30.0%	13.5%	4.3%

Source: www.mii.gov.cn

Telecom Carriers: Vision

- Enhance profit-generating services
- **Convergence** between
 - **Services**
 - Double Play → Triple Play → Quad-Play
 - Anywhere, Any time, Any device
 - **Networks**
 - Towards IP-centric, Fixed and Mobile...
 - Telecom and IT **Industries**
- More **Intelligence** in services, control & transport
- **Broadband** Applications
- Bridging the “**digital gap**” between urban and rural, educated and uneducated, poor and wealthy.

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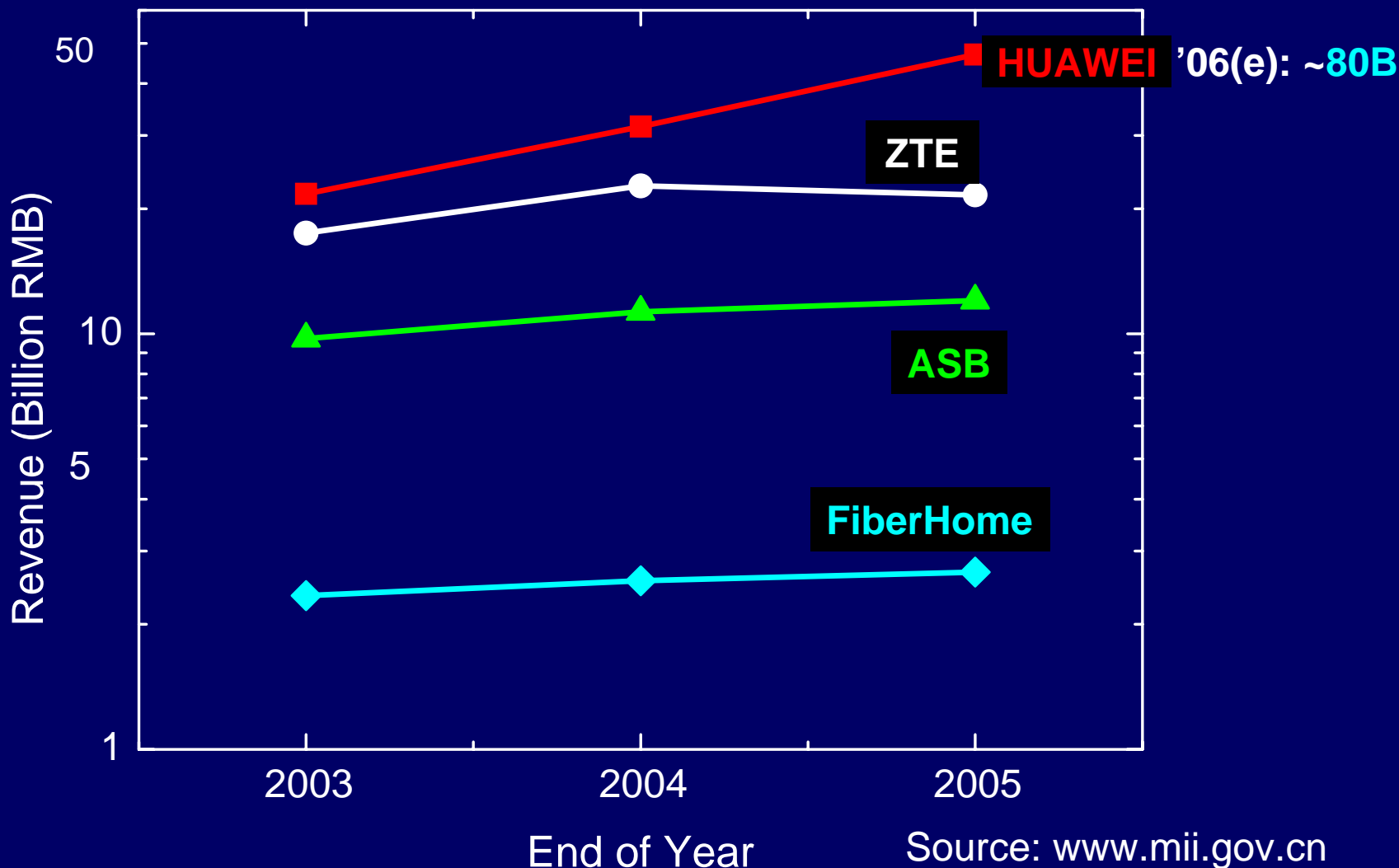
OFC System Vendors



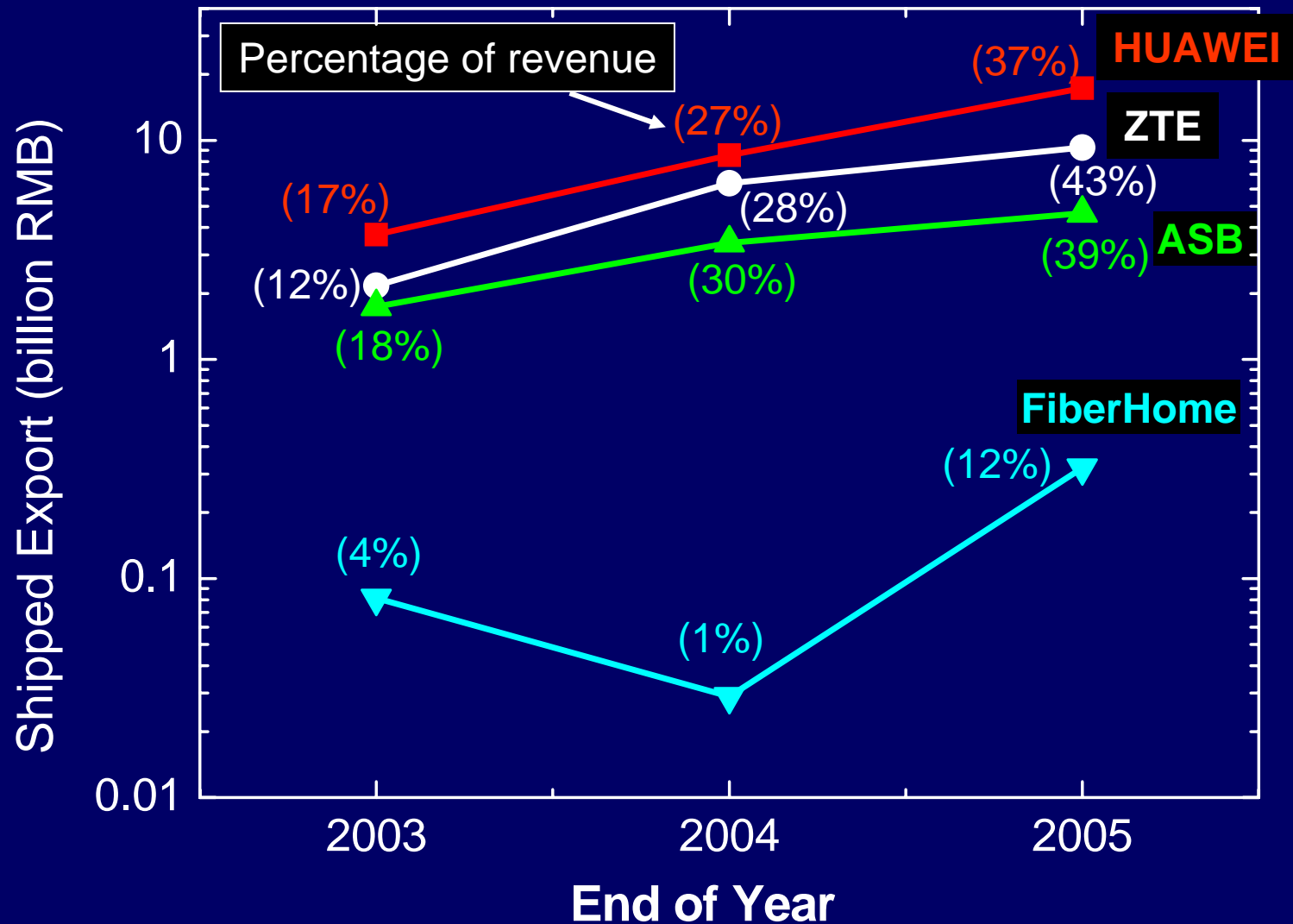
ASB

Revenue of System Vendors

- Revenue of Huawei growing exponentially: ~ +50%/yr



Shipped Export of Major Vendors



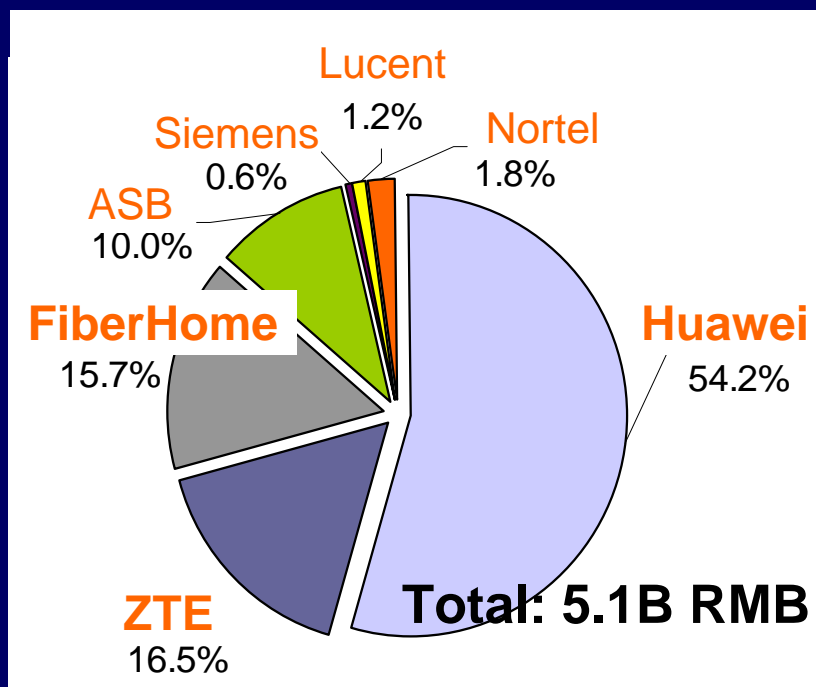
DWDM Backbone in Russia



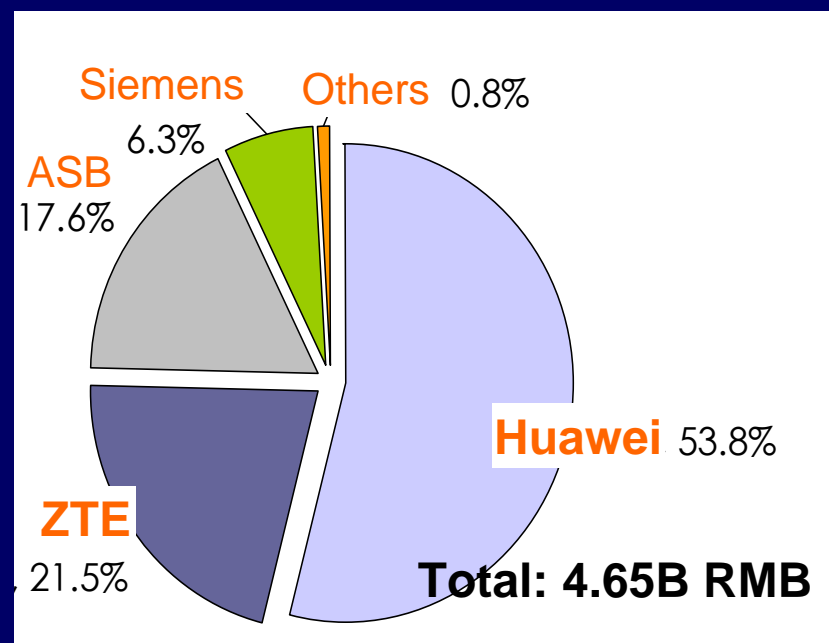
- Huawei's OptiX BWS 1600G System/ SuperWDM technology
- 10 repeatered sections w/ length >1000km, max 1700km
- Longest amplified span=220km with high-power amp. & Raman technologies
- Highly reliable OTU 1+1 network protection.
- 12,000km installed and in service within 8 months. Courtesy: CT Cai, Huawei

Domestic Equipment Market 1H '06

Optical Transmission



Fixed Network Switching/Access

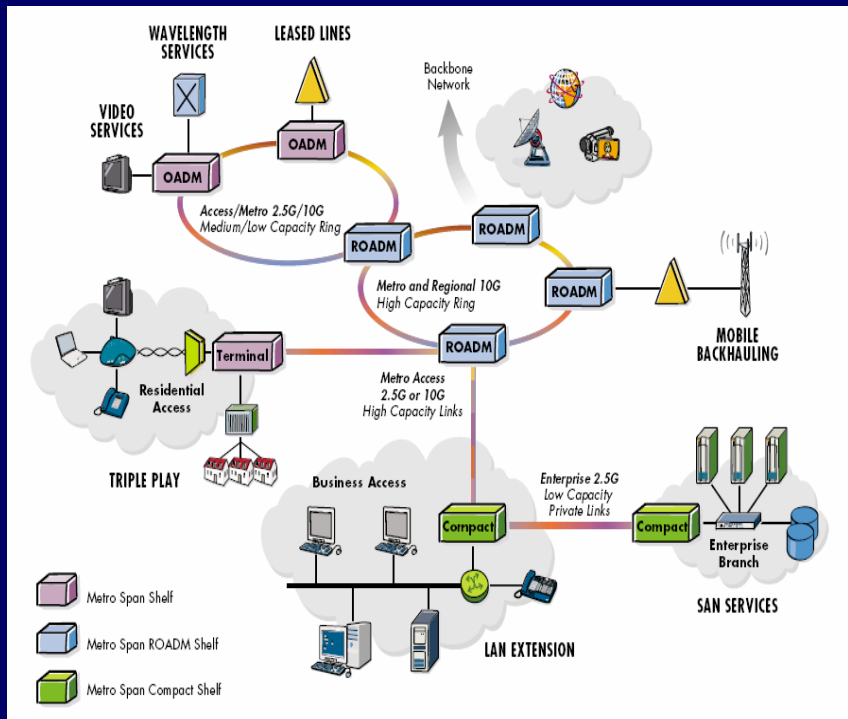


- Huawei + ZTE + FiberHome >86%

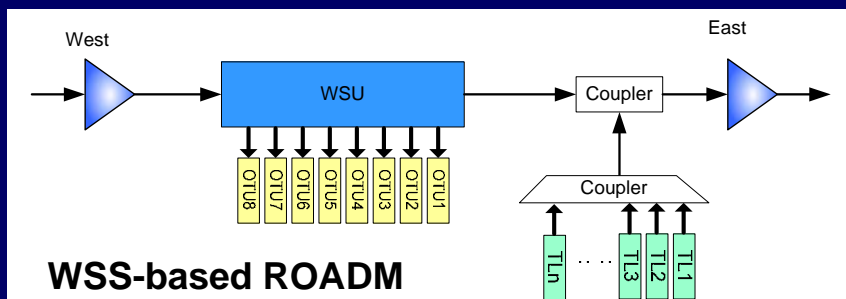
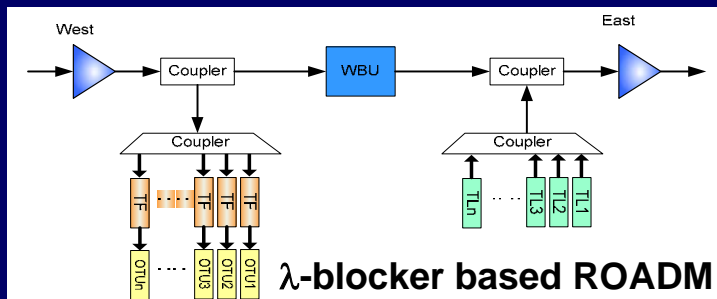
- Huawei + ZTE >75%

- FiberHome holds ~50% domestic FTTH market share.

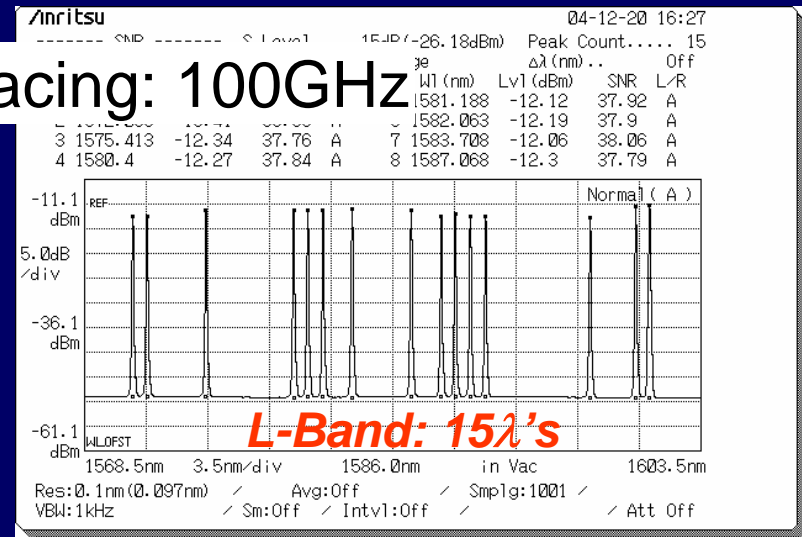
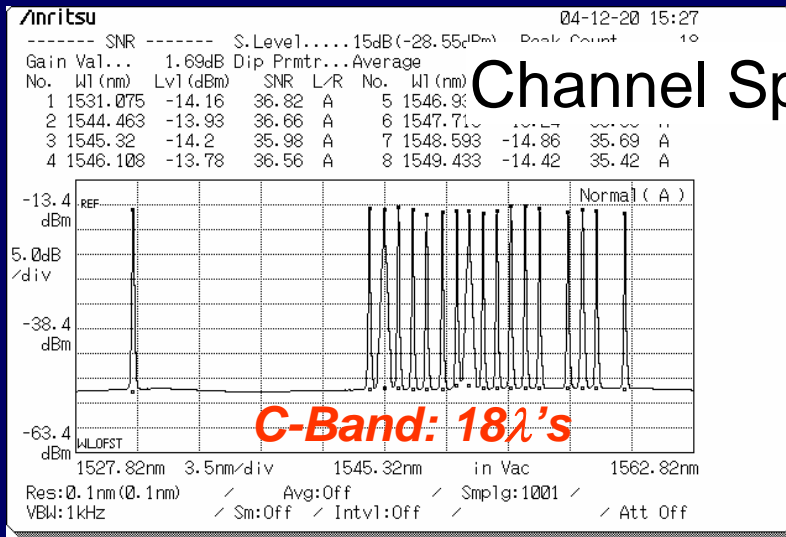
Metro-Core Network



- Up-gradable to 80- λ 's
- Multiple service access
- Fast & flexible service reconfigurable thru **ROADM**, λ - and sub λ -switching & **ASON**...
- Full C-Band 80- λ **tunable OTU**
- The only system vendor providing **6** ways of protection.
 - Ring based (3)
 - Line based (2)
 - Client side based (1)



3.2Tb/s (80x40G) DWDM Link between Shanghai & Hangzhou (250km)



- Part of **3TNet** Project:
 - Development, integration and field trial of **Tb/s [WDM, ASON, IP Router]** in Yangtze River Delta.
- Mod.: NRZ+SFEC
- OA: EDFA+RA

- Equalization: DGE
- Fiber: **G.652B**
- DC: DCM+Tunable FBG
- PMD Comp.: Dynamic
- Max regen. distance: **800km**
- **Operational Dec '05.**

Source: Prof. Q Mao, FiberHome

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IPTV in Mainland China

- Licensee (**3** under *State Agency of Radio, Film & TV*):
 - Shanghai Media Group (**SMG**) : Apr '05
 - **CCTV Int'l**: Apr. '06
 - Southern Media Group (**Southcn**): Jun '06
- **Cooperation** among Telcos and CATV operators
- Total Subscribers: 2006: **550k**, 2010(e): **5~10M**
- Example: **Shanghai Telecom + SMG IPTV Service**
 - No. of subscriber (e): **70k** (end '06)
 - Subscription fee: **RMB 60/month** (4 times of regular TV)

Source: www.lmtw.com

FTTx and PON: Telco's Vision

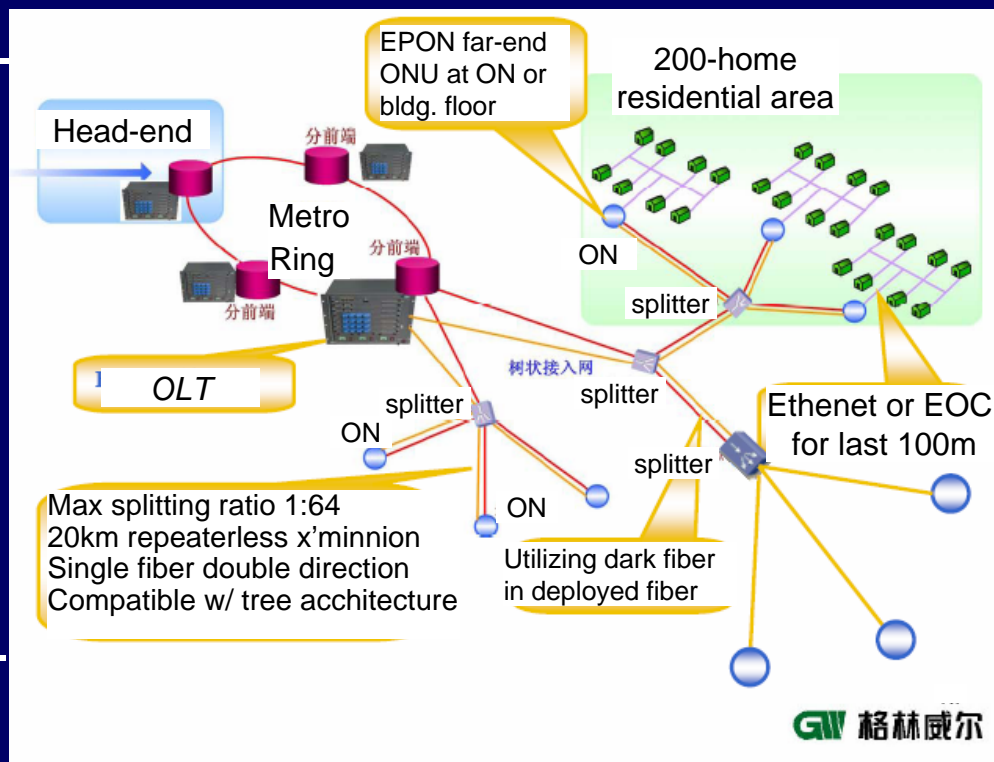
- **FTTH will be the long-term tech of broadband access**
 - High capacity / Low EMI
 - Long distance
 - Low OpEx
- **Infeasible in near term**
 - Deployed copper base for DSL
 - High cost
 - Equipment: RMB 2~3K/line
 - Link: RMB 1~3K/line
 - Weak demand on high BW
 - Less matured
- **EPON: PON tech of choice.**
 - Technical and industry chain maturity.
 - Lower cost than GPON
 - Trial: covers ~20k dwellings w/ ~10% take rate.
- **Major equipment vendors:** FiberHome, Huawei, ZTE, GW...
- **Major Customers:** high-end residential area, CBD, Internet-bar clusters & rural information society.

Courtesy: L Zhang, GW

FTTx & PON: Cable Operator's Vision

EPON for Dual-Way Rebuild

- Dual-way rebuild for TV + hi-speed data by EPON + Ethernet
- Deployed in two cities (Zibo and Qingdao), Shandong Province.
 - About **400 k** subscribers each.
 - Equip. vendor: **Huawei**



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IP/MPLS Transport Network

- Key to carrier transformation & service convergence.
- CT:
 - CN2 (upgraded version of ChinaNet): Nat'l IP/MPLS backbone network deployed Aug '06 with 1.3B RMB investment.
- CM:
 - 2nd Internet: Service routers based on IP/MPLS deployed in 13 provinces since Dec. '06 for data, video and FMC services.

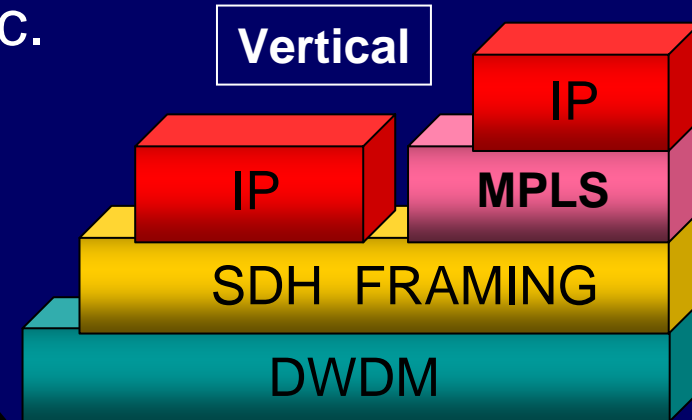
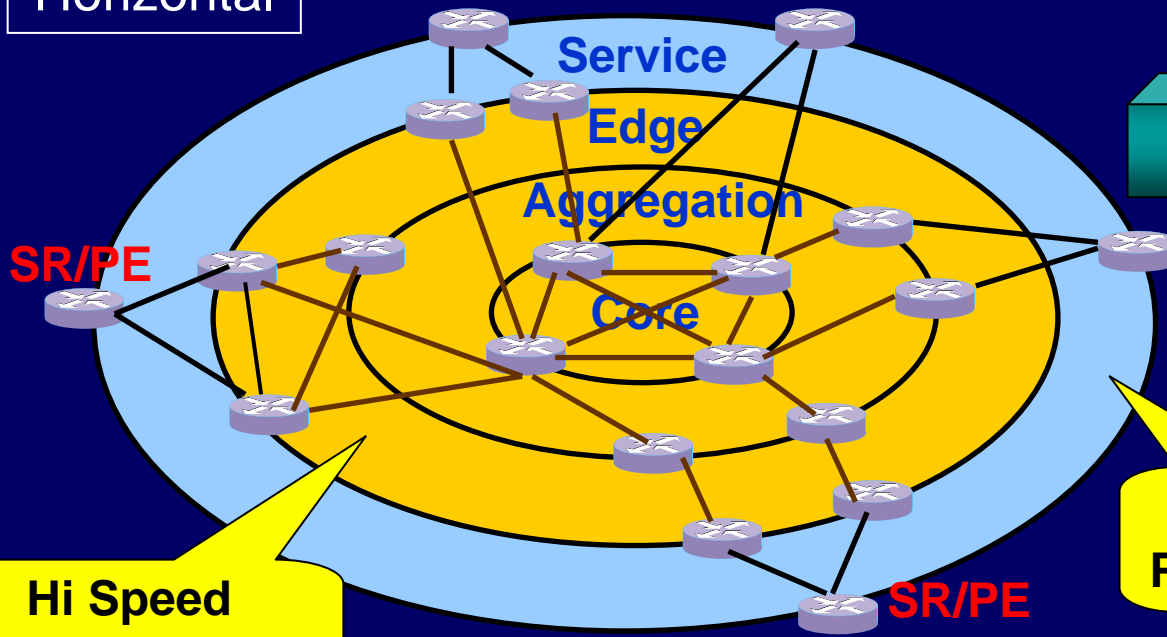
CN2 Network Topology



Connecting the World

- Horizontal: 2 functional planes and 4 structural layers.
- Vertical: MPLS employed for VPN traffic.
- MPLS FRR (fast re-route) < 50ms.

Horizontal



Hi Speed
Data Forwarding

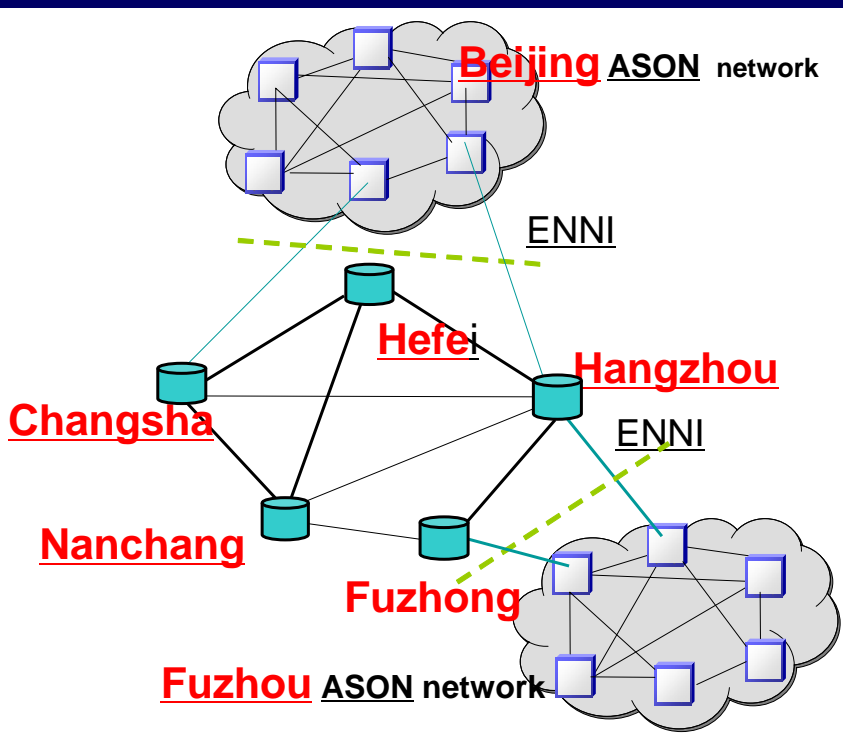
Service
Provisioning

No. of routers: Total: 865 , P: 439,
SR/PE: 402, Public RR: 12, VPN RR: 12

ASON Trial Network

Nov 2006

Major topics



- Equipment stability/reliability
- Protection/restoration time in large network
- Inter-area connection (w/ and w/o ENNI)
- Service (OVPN / BoD) test and demo
- Network maintenance

Courtesy: C. L. Zhang, CT, Oct 2006

Telemar National Intelligent Backbone



Telemar--Largest fixed operator in Brazil w/ **15M** fixed & **12M** mobile subscribers.

Benefits

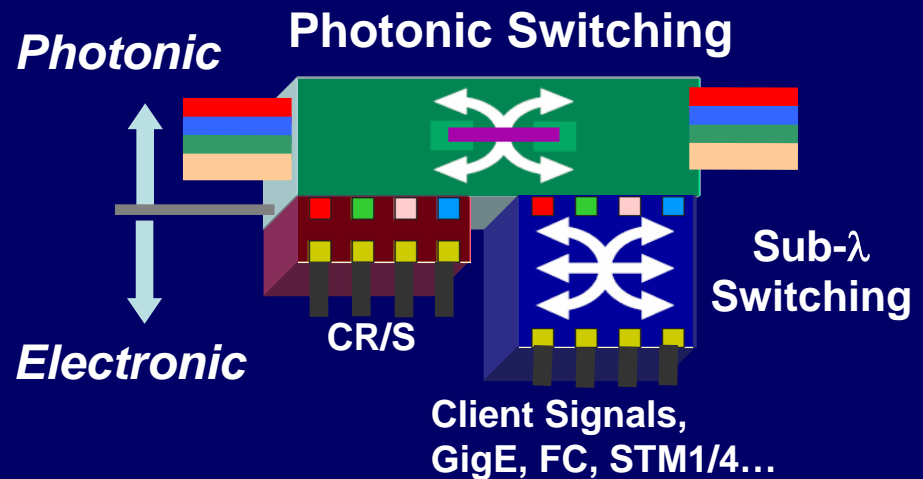
- ❖ Anti-multi-point failure
- ❖ 100+ **SLA** services for important enterprise clients: TAM Airlines, Visa Card, Banks, Fiat Motors etc.
- ❖ Lower OpEx with *intelligent* software
- ❖ Easy to plan and simulate current network with Huawei **ASON planning tool**.



Courtesy: CT Cai, Huawei

NG Transport Network: Vision

- Packet-based
- MESH
- Multiple Service
- High speed / high capacity link & switching.
- Intelligence in transport, control & mgmt planes
- Network OAM



Courtesy: Dr. JY Wang, ZTE

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National Research Programs

-  **NSFC Program**
 - Funding by **NNSFC** on *basic research*.
-  **973 Program** (Nat'l Basic Research Prog.)
 - Funding by **MoST** for *applied basic research*.
-  **863 Program** (Nat'l Hi Tech R&D Prog.)
 - Funding by **MoST** for *Industry-oriented R&D*
- **Nat'l S&T Supporting Program**
 - Funding by **MoST** for R&D and application of key techs for *public welfare* and *cross-ministry* industrial technol.

NNSFC=Nat'l NSF of China

MoST=Ministry of Science & Technology

National Labs



<http://www.tnlist.org.cn>



<http://wnlo.hust.edu.cn>

- Tsinghua Nat'l Lab for Information S&T

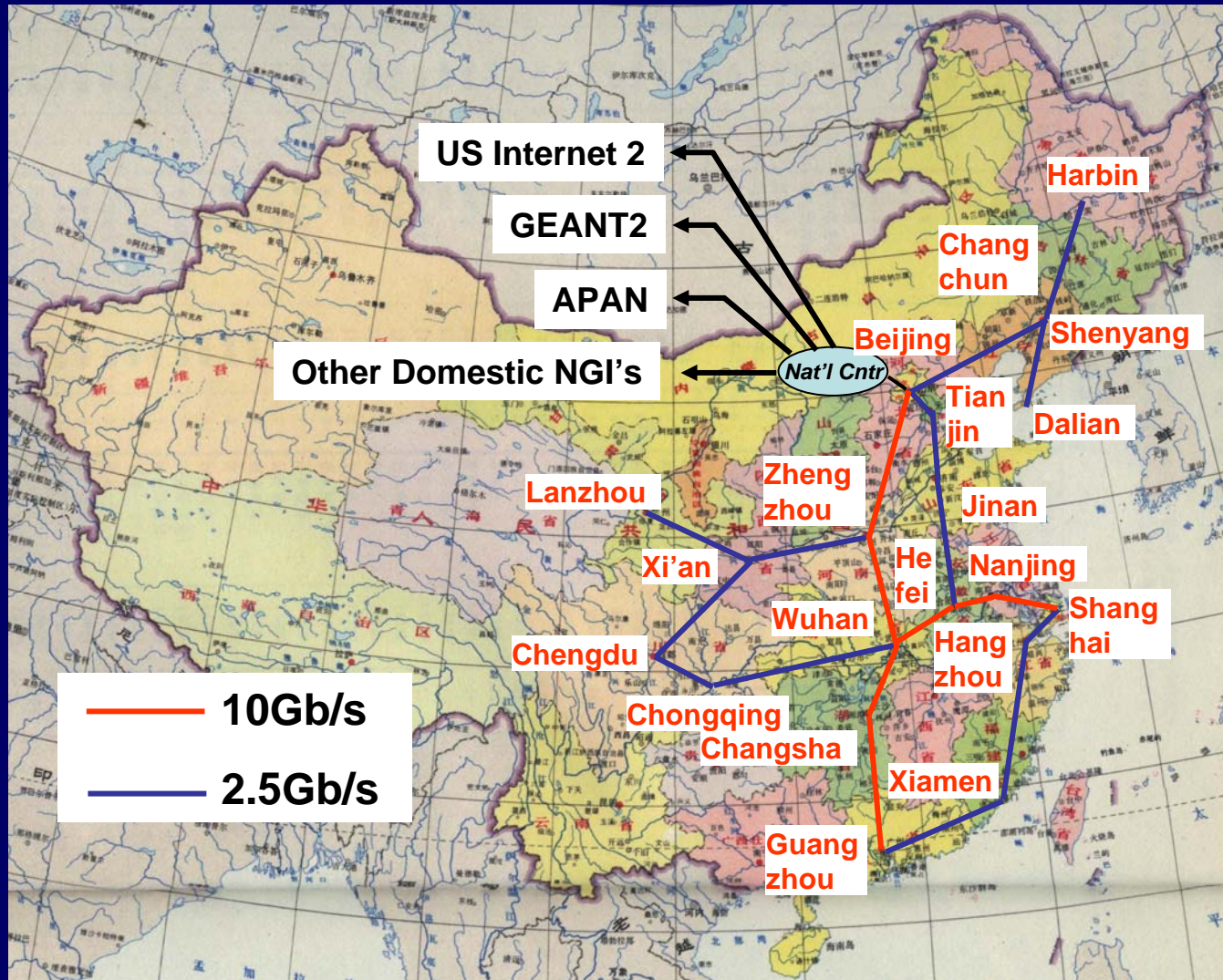
- Communication System & Network
- Optoelectronics
- Micro/Nano Electronics
- NG Internet
- Bio-information
- Grid Computing
- ...

- Wuhan Nat'l Lab for Optoelectronics

- Optics engineering
- Electronic S&T
- Info. & commun. Eng.,
- Biomedical Science
- ...
- HUST, WRIPT, Wuhan Math/Phys Res Inst (CAS), HZO/E Res Inst.

China Education & Research NETWORK 2

All IPv6 backbone demo project of CNGI ('03-'06)



China Education & Research NETWORK 2

All IPv6 backbone demo project of CNGI ('03-'06)

- 8 Co-sponsors (NSFC, MII, CAS, CAE, MoST, MoE...)
- 25 participating universities (PI: Tsinghua U)
- Features
 - Biggest all-IPv6 backbone network worldwide
 - End-to-end IPv6, IPv4, IPv4/IPv6 connection.
 - IPv4 over IPv6 tunneling tech.
 - Improved network reliability and security.
 - 80 % core routers domestic-made.
 - 100 universities connected.

Source: Prof. J. P. Wu, <http://www.media.edu.cn>, Aug 30, '06

Switching-Related Research

Tech	863	NSFC	Budget
WDM	✓		~ \$ 8 million
OADM / RING	✓		
OXC / MESH	✓	✓	
ASON	✓		
NG-SDH	✓		
OBS (BUPT+SJTU, UEST)	✓		~ \$ 1.5 million
OLS (THU)	✓		
OPS (SJTU+THU)		✓	
TWIN (SJTU)		✓	~ \$ 0.2 million
O-Grid (SJTU, BUPT)	✓	✓	

TWIN = Time-domain Wavelength Interleave Network, similar to OPS

O-Grid = grid computing over optical networks (ASON, OBS...)

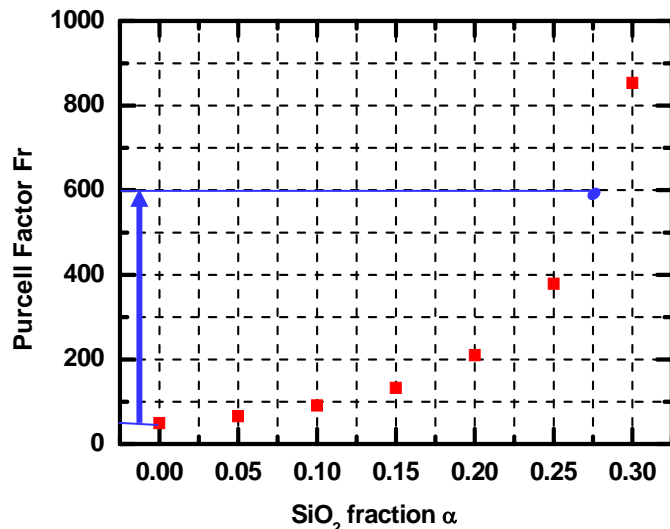
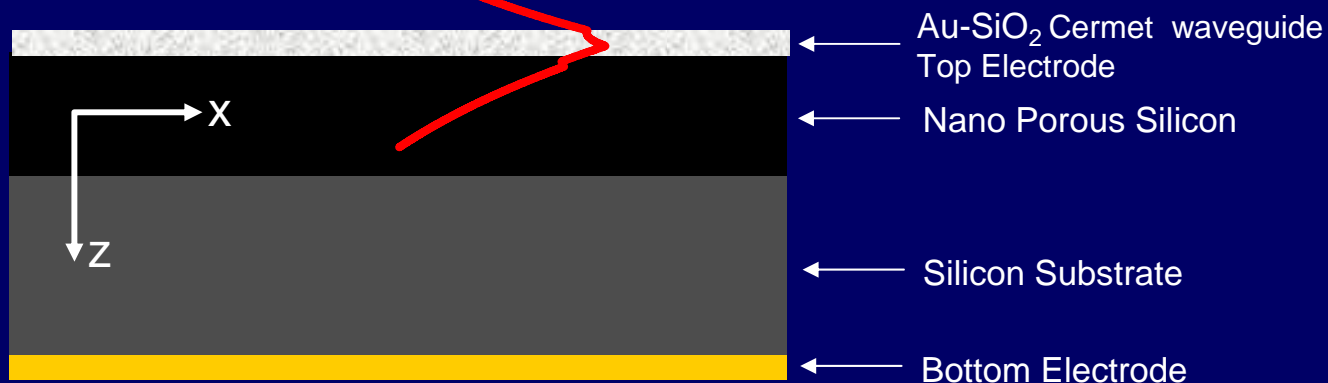


Some Academic Research Topics at Tsinghua University

Topic	Author / Publication	Supported by
ASON	N. Hua, et al., OFC'07 NWB5	863
Microwave Photonics	J. Sun et al., <i>PTL</i> , <u>18</u> , 2587, '06. T. Wang et al., OFC'07 JThA59	NSFC Self-supp.
OBS	Y. Du et al., OFC'07 JWA77	863, HHI
OCDMA En/Decoder	Y. Dai et al., OFC'07 JWA28	TNList
PC Fiber	S. Yang et al., OFC'07 OThA6	NSFC, 973, TNList
Quantum Encryp. Comm.	C. Peng et al., <i>PRL.</i> , <u>98</u> , 010505, '07	NSFC, 973
Radio Over Fiber	K. Wang et al., OFC'07 JWA62	973
Silicon Photonics	X. Hu et al., <i>APL</i> , <u>89</u> , 081112, '06	973
Slow Light	Y. Wang et al., OFC'07 JWA13	973

Silicon Photonics: Enhanced Photoluminescence from Porous Silicon by Au-SiO₂ Cermet Waveguide

XL Hu et al., *Apply Phys. Lett.* **89**, no. 081112, 2006, Supported by **973** Program



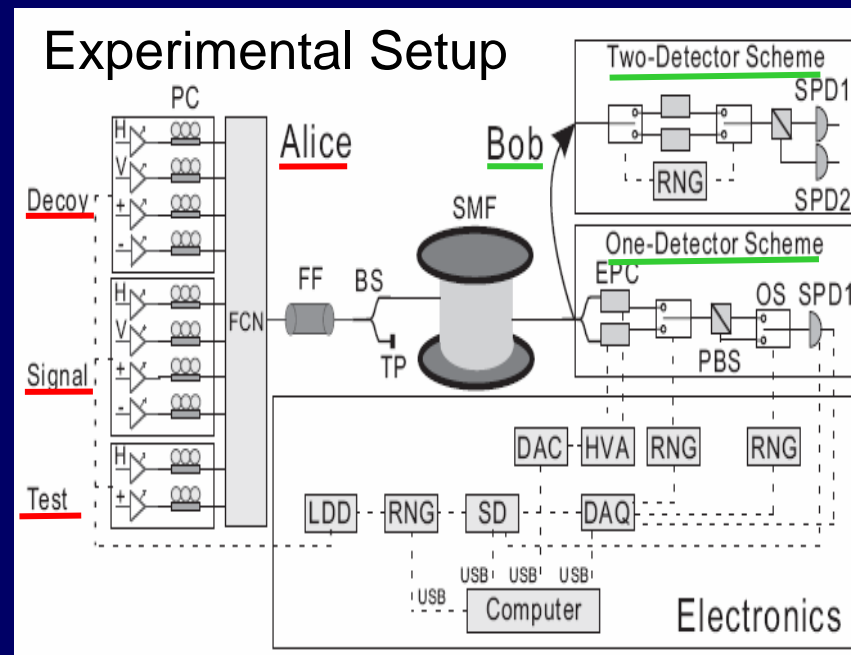
Surface Plasma associated Purcell Effect

- Previous work: Au waveguide only
 - Luminescence **~400nm**
 - Low Purcell factor
- Current: Au(1- α)-SiO₂(α) cermet waveguide
 - Luminescence **~800nm**
 - **Order-of-magnitude higher Purcell factor**

Long-Haul SMF Quantum Encryption Communication

C. Z. Peng et al., *Phys. Rev. Lett.*, 98, 010505 (2007)

- Polarization-encoding-based one way *decoy state* QKD, offering *unconditionally secure* final keys.
- No single-photon source required.
- Automatic PMD compensation.
- 10 authors from 5 institutions
- Jointly supported by NSFC, CAS and 973 Program.



Detection Scheme	L (km)	Key rate (b/s)
Double detector	102.7	8.1
Single detector	75.7	11.7

Papers from M. China

Journal	2003	2006
Optics Express	7.7%	12.9%
Optics Letters	6.1%	10.1%
IEEE Photon. Tech. Lett.	7.7%	10%
Jour. Lightwave Technol.	4.0%	8.1%

Conference*	2003	2006
OFC	4	23

* Including symposia, workshop, oral and poster

Courtesy: J Sun, Tsinghua University

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Concluding Remarks (1)

- Both the OFC industry and academic research are advancing towards world-class.
- Mighty Driving Forces
 - **Population** (estimated 1.315B as of end '06)
 - **Fast** growing economy: **GDP '06: 209.4T RMB** (16K RMB per capita)
 - **Increasing demand** from all walks of life, including huge rural population
 - **Broadband** services evolve into **consumer** products.
 - State policies **encouraging**
 - Emphasis on **local innovation**
- **NGN** with multiple, converged, BB & intelligent services

Concluding Remarks (2)

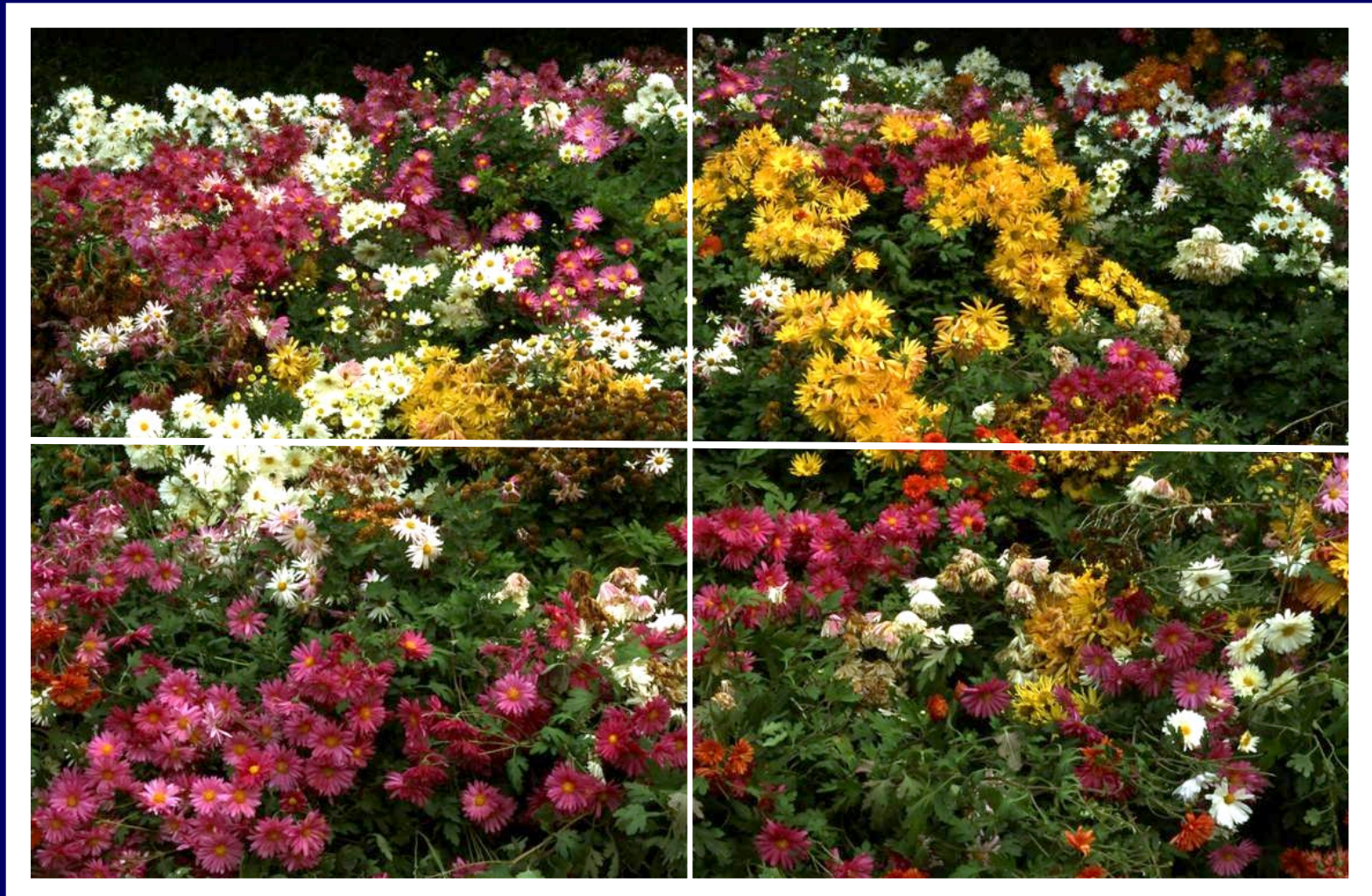
- **Transformations** under way
 - Telecom Carriers → Info Service Providers / Players
 - Equipment Vendors → System / Service Solution Providers
 - Academia → more innovative, interdisciplinary and link w/ industry
- **International** activities and co-operations benefiting industry and academia.
- **Challenges:**
 - **Regulatory**, IP and standards **issues** ...
 - **Balance of interests** among
 - Fixed and mobile carriers
 - Telco and CATV Enterprises
 - **New services and products** for targeted applications and **functionality**, high-performance + low-cost, and **window-of-opportunity** timing.

“If Winter comes, can Spring be far behind?”

- Percy B. Shelley, quoted by Dr. Tingye Li at OFC 2002 Plenary



Which Flower or What Bouquet Will Satisfy Your Customers Tomorrow -- and Days After Tomorrow?



THANKS !

deefcc@mail.tsinghua.edu.cn