The Wireless Opportunity

WCA Symposium
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Agenda

- **Industry Perspective**
  - Environment
  - Wireless Access Methodologies
  - Challenges & Opportunities

- **Intel Activities**
  - Products/Technologies
  - Investments
  - Standards/Regulatory

The Spiral of Innovation

Mobility, Wireless & Broadband

Internet

Multimedia

Graphical User Interface

Command Line

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As we were Innovating …

NASDAQ 100 Index
May'97 to Present
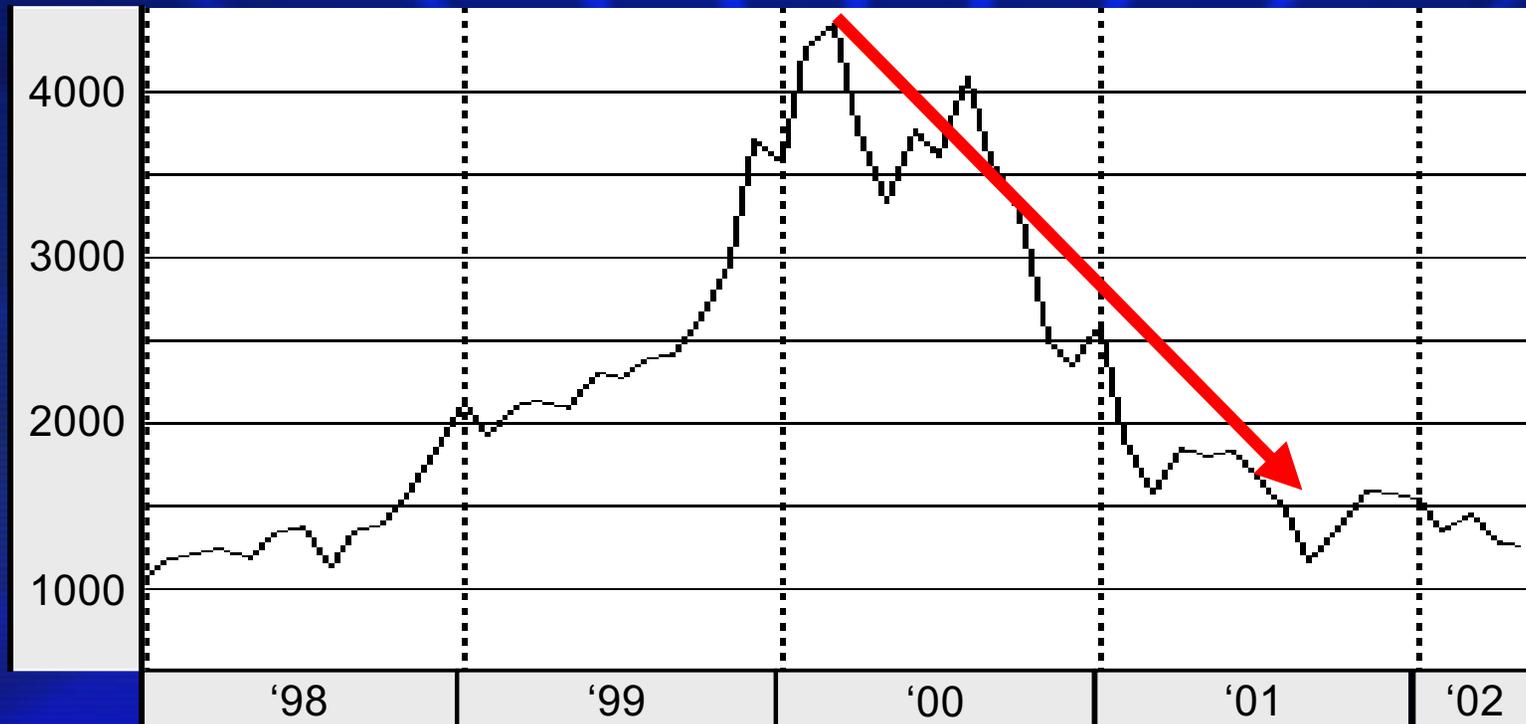
History Lesson

Market Development for New Technologies

Growth (y-axis) vs Time (x-axis)

Early Adopters → Irrational Exuberance → Turbulence → Sustained Growth
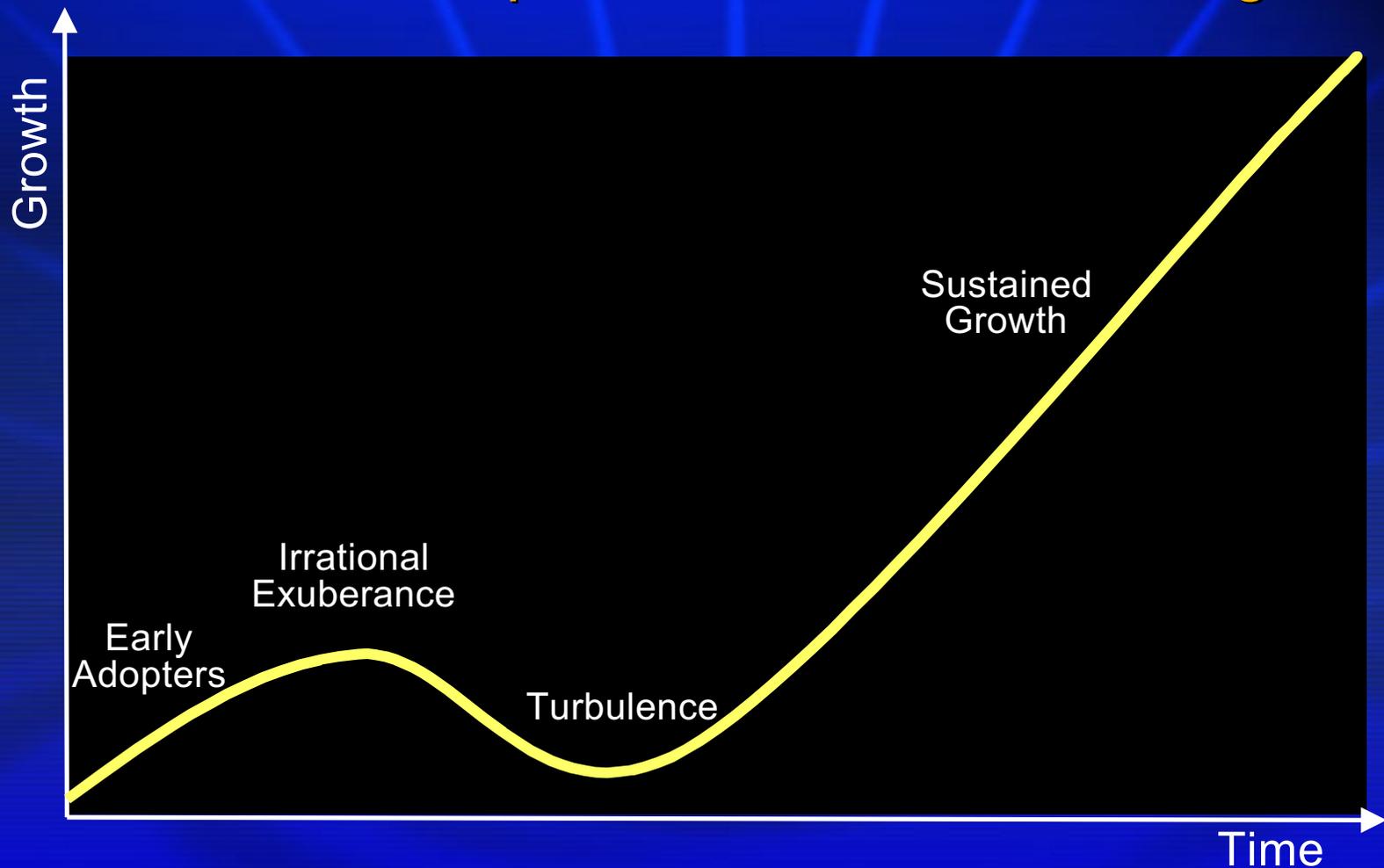
Courtesy of Brian Arthur

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Wireless Access Methodologies

Wireless Deployment Options
For Residential/SOHO BB Access in < 10GHz Licensed Bands

- Service Provider must devise a cell-based deployment plan
- Cell plan determines → BST & CPE
- All systems: Point-to-Multipoint, shared bandwidth systems

"Super-Cells"

CPEs
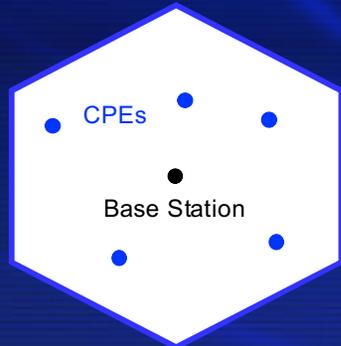
Base Station

r ~ 30 miles

OR

"Macro-Cells"
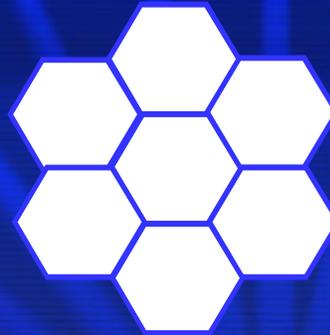
r ~ 5 miles

OR

"Micro-Cells"
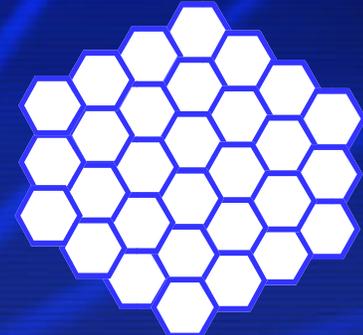
r ~ 1 mile

	TradeOffs	
Immediate area coverage	← →	Phased area coverage
A few expensive base stations	← →	Lots of cheap base stations
A few backhaul connections	← →	Lots of backhaul connections
Low "data density"	← →	High "data density"
Simple interference mgmt	← →	Complex interference mgmt

The World of Licensed & Unlicensed

Wireless Broadband Trends
Domestic

- Unlicensed Spectrum → WISP's Growth
  - ~2500 WISPs projected in ~6500 markets*
  - Enterprise, Public Access, Residential
  - Some limited Last mile access in areas underserved by cable & DSL

- Wireless T1-level services to business
  - Competitive Advantages

- Major U.S. carriers re-engaging
  - Better price/performance of equipment, revised business strategies

Wireless Broadband Trends
International

- Licensed deployments mostly, but unlicensed growing

- Competing head-on with wireline access in major urban centers
  - Japan, So. Korea, Spain, Latin Am., Eastern Europe, PRC, India

- Local operators in developing countries deploying wireless, instead of wireline
  - Especially for green field deployments
  - Voice is as important as data

Wireless Access Methodologies

Typical User Data Rate

Broadband

Narrowband

LMDS

MMDS

Satellite

W.LAN

Industry Excitement!

Service Target

Broadcast

802.16

Proprietary

Bluetooth

3G

2.5G

2G

Fixed

Local Area

Wide Area
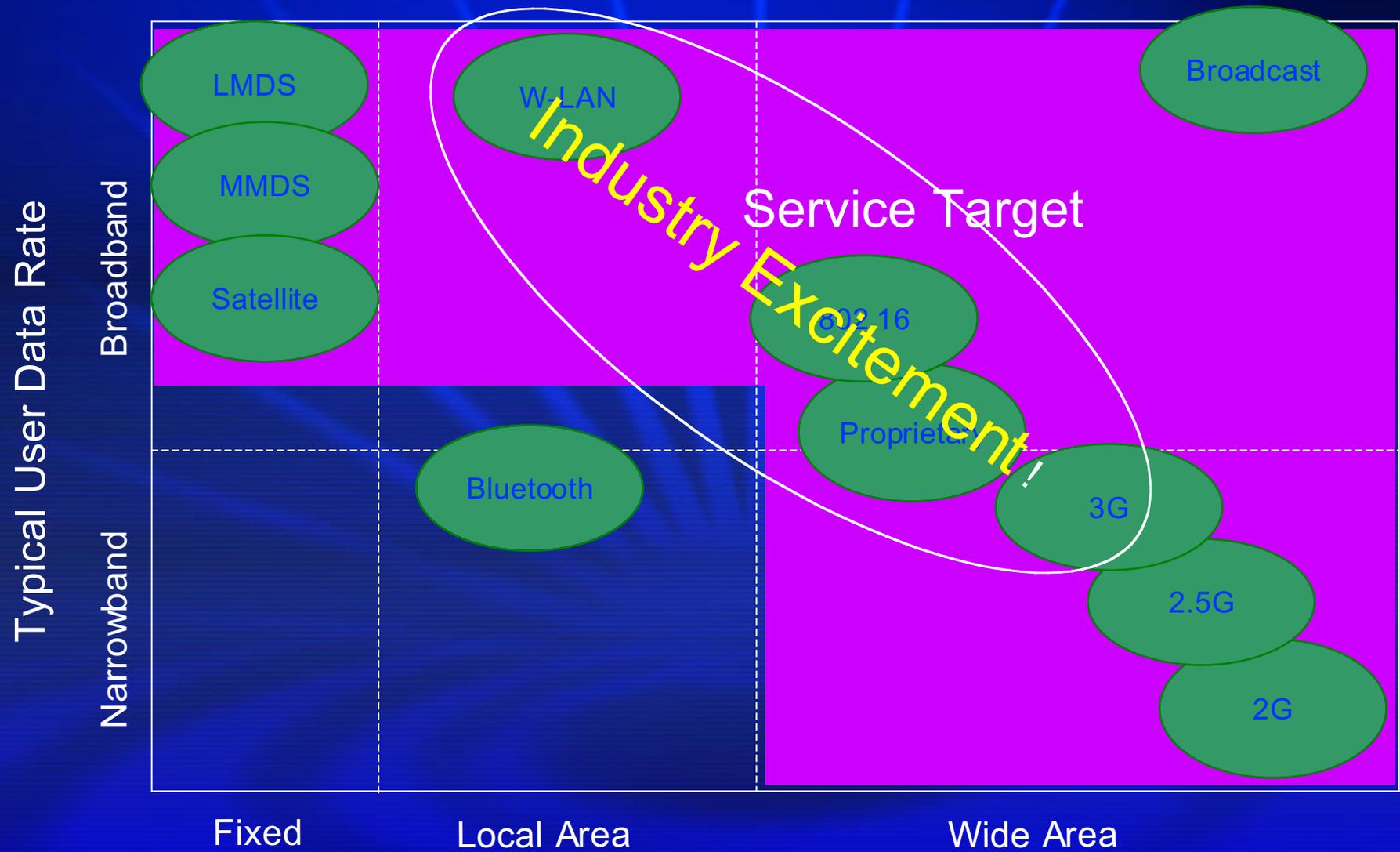
Which one changes the rules of the Industry ?

802.11 x

802.16

Cellular Based

802.11 Hotspot Growth

This is getting revised UP quarterly !

Legend:
- Asia
- Europe
- US

Data values:
- 2000: (small)
- 2001: 7K
- 2002: 17K
- 2003: 37K
- 2004: 65K
- 2005: 98K
- 2006: 144K

Y-axis: 0 to 160000
X-axis: 2000, 2001, 2002, 2003, 2004, 2005, 2006
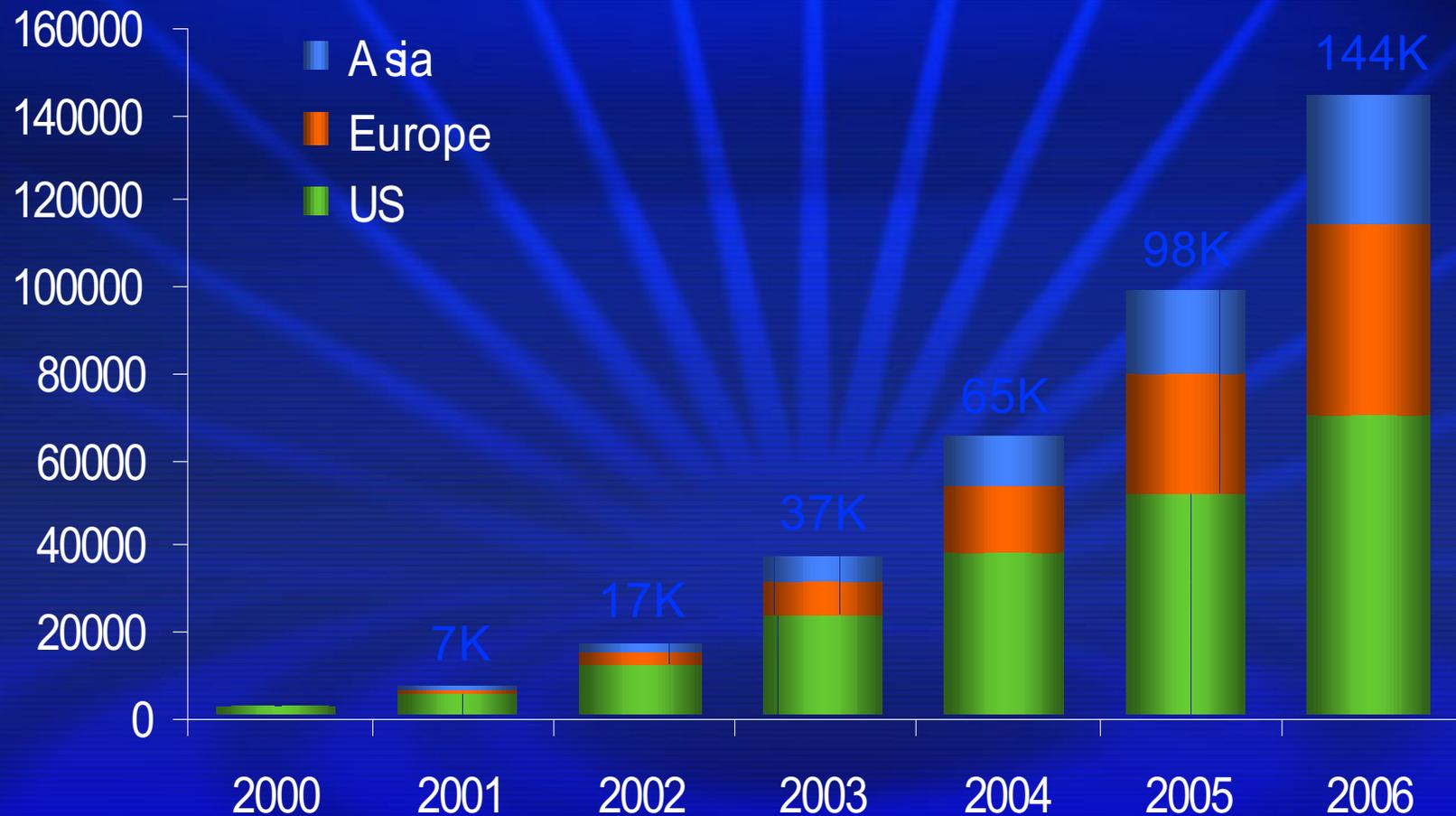
Source: BWCS Ltd. 2002

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802.11 Market Segments

ENTERPRISE

Network Access & Bridging

PUBLIC ACCESS

Accessing Internet and Email

RESIDENTIAL/ HOME OFFICE

Sharing Broadband Internet Connections & Media
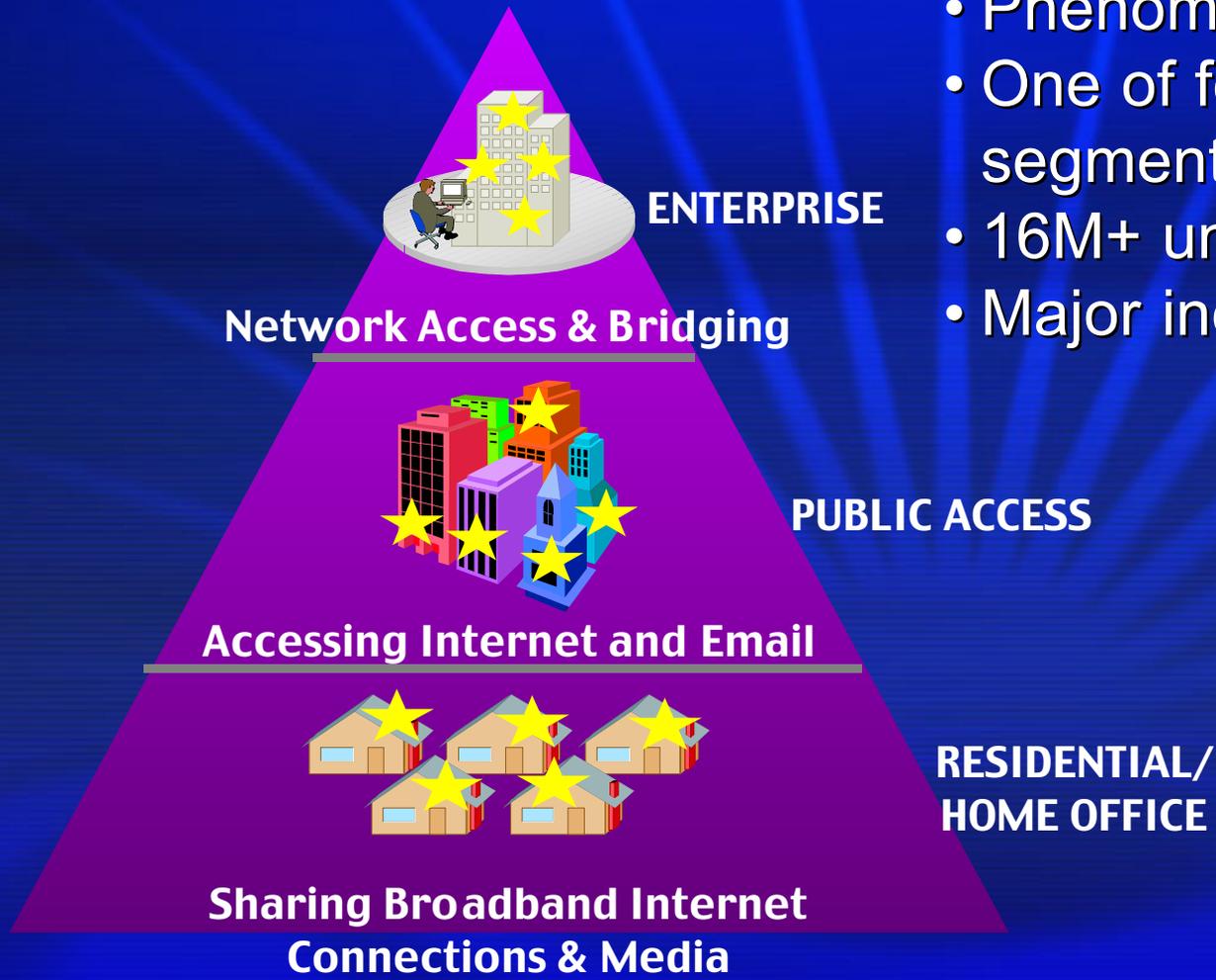
- Phenomenal growth
- One of few wireless comm segments up this year
- 16M+ units sold in 2002*
- Major industry investment

* Intel projection based upon 1H'02 shipment data from Gartner Dataquest, 11/02.

802.11 Challenges = Opportunities

Ease of Use
- Complex configuration
- Power hog

Security
- Perceived insecurity
- Flaws in standards

AAA
- Roaming / exchange
- Login/Network access

Availability
- Spotty coverage
- QoS

Awareness
- User accessibility

Which one changes the rules of the Industry ?

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802.16

Cellular Based

802.16 Wireless Access

Worldwide < 11 GHz Subscriber Base by Region
(802.16a and Proprietary)

Legend:
- Middle East/Africa
- Asia
- Europe
- Americas

Y-axis: Millions (0, 2, 4, 6, 8, 10, 12)
X-axis: '03, '04, '05, '06, '07, '08
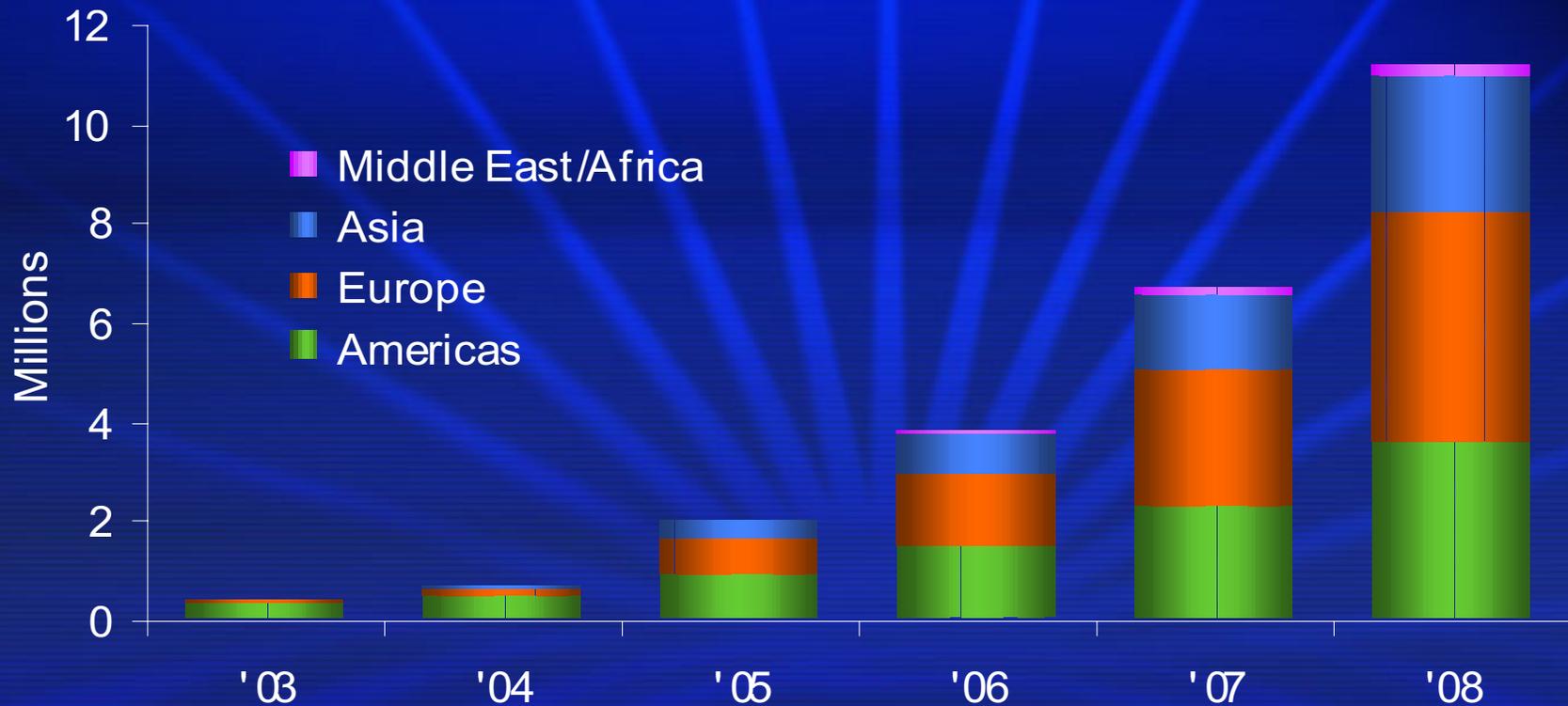
Assumptions
- 802.16a standard is adopted -> reducing customer premise equipment price
- Does not consider Hotspot subscribers

Source: Intex Management Services primary research for Intel, December '02. Based upon April '02 report, "The WW Market for Broadband Wireless Access, 2002".

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802.16a Last Mile Market Segments

- Market still early stage
- Dramatic product improvements since 1st gen
- 802.16a standard opens door for volume components
- Cooperation & promotion amongst vendors is key

T1 LEVEL SERVICE for ENTERPRISE

FRACTIONAL T1 for SMALL BUSINESS

RESIDENTIAL/SOHO BROADBAND

WIRELESS BACKHAUL for Hotspots

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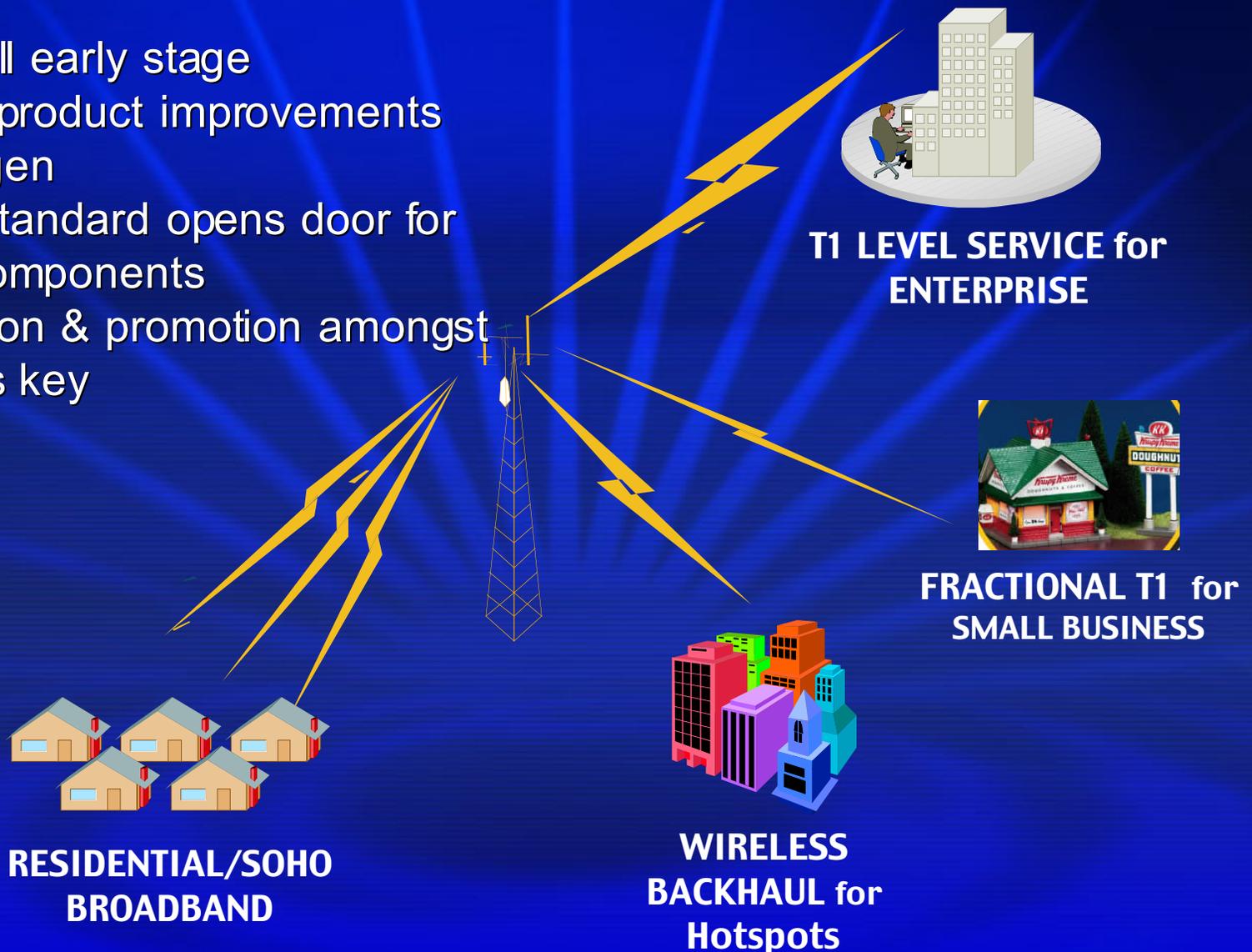
802.11 Drives Demand for 802.16a

- Wireless broadband key to fast deployment of hotspots where wireline not available
- WLANs within the home or business increase appetite for broadband access

802.16a

ENTERPRISE 802.11 WLANs

802.16a

802.16a

SMALL BUSINESS 802.11 WLANs

RESIDENTIAL AND HOME OFFICE 802.11 WLANs

**802.11 HOTSPOTS:
Cafes, Campuses
Hotels, Airports
Conventions
Centers, ...**

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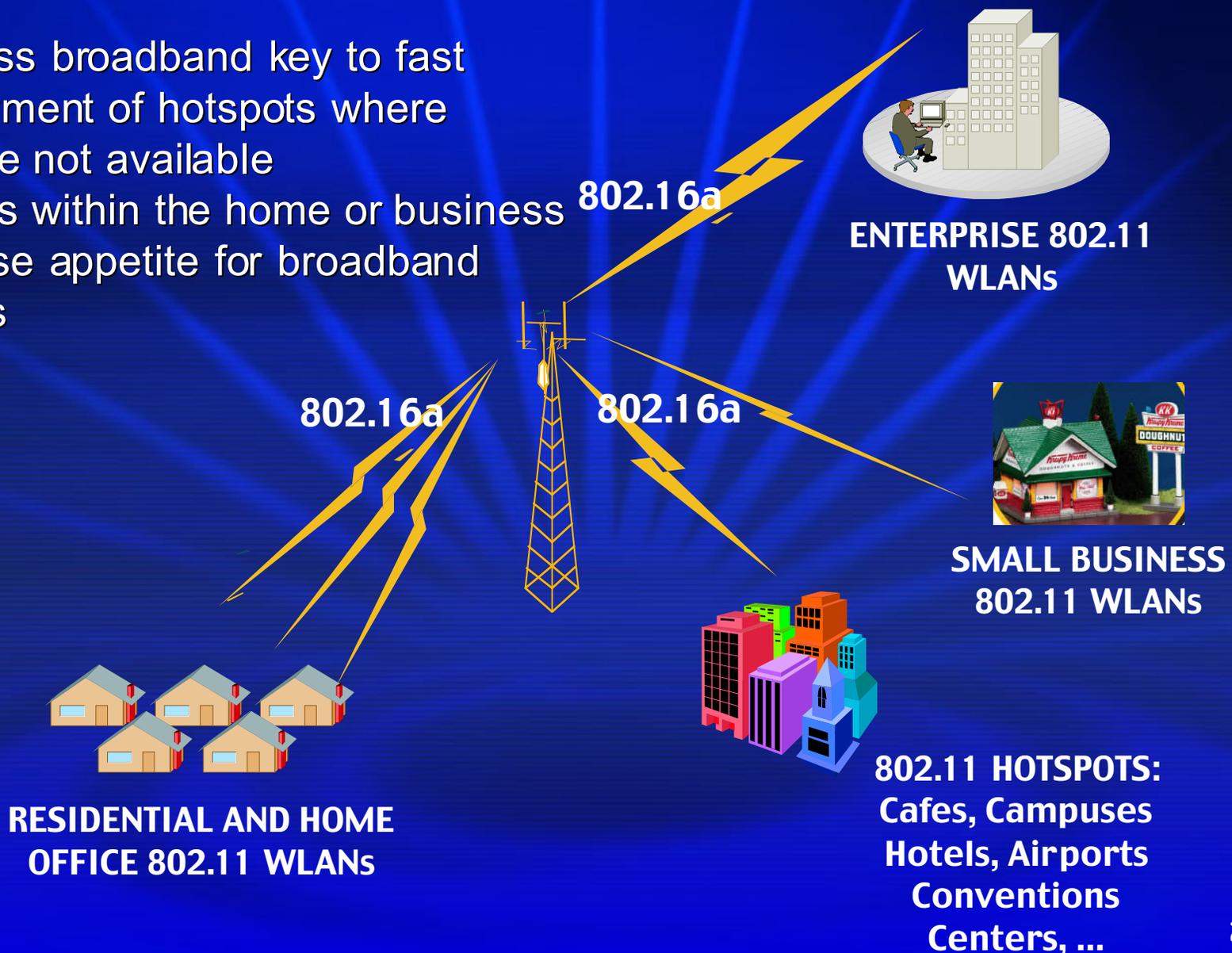
802.16a Challenges = Opportunities

Cost	• Proprietary solutions have hampered cost reductions
Ease of Install	• Indoor installation reduces throughput • Outdoor installation requires truck roll
Scalability	• Easy sectorization • Seamless network management
Availability	• Spotty coverage • Non-line-of-sight performance
Interoperability	• Consolidation around 802.16a standard

Which one changes the rules of the Industry ?

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Cellular Based

Cellular Based Access

- Near Ubiquity

- Known Usage Models

- Ease of Use

- Mobility Based applications

BUT

- HUGE Licenses for data access

- Need for New Business Models

Today's Wireless Performance

	Channel Bandwidth	Maximum Data Rate	Maximum Bps/Hz
802.11a	20 MHz	54 Mbps	~2.7 bps/Hz
802.16a	10, 20 MHz; 3.5, 7, 14 MHz; 3, 6 MHz	70 Mbps*	~5 bps/Hz
EDGE	200 kHz	384 kbps	~1.9 bps/Hz
CDMA2000	1.25 MHz	~2 Mbps	~1.6 bps/Hz

* Assuming a 14 MHz channel and ~ 5 bps/Hz

802.11 Vs 3G
Economics of Access

Single user handset data rates (Mbps)

HiperLAN2	27.0 *
802.11b	5.5**
Bluetooth	0.35 **
3G (UMTS)	0.144
2.5G (EDGE)	0.144
2.5G (GPRS)	0.043

Average cost of data traffic ($ per MByte)

3G* : 0.20-0.25

WLAN : 0.03-0.06

Assumptions for 3G cost

- WCDMA upgrade from existing GSM network
- Cell cost is around $400,000, amortized over 8 years and includes all shared network costs***
- Cell capacity of 6,075 Mbytes per day ****

* Downlink only, Symmetrical link speed is 432 kbps
** Single user data rates are 50% of theoretical

*** Network backbone, PDSN, PDGN, RNC, transceiver/transcoders, servers, OS, software licenses

**** 15MHz of spectrum deployed, 3 sectors per cell, 0,2 bits/second/Hz/sector, 50% peak hour utilization rate, peak hour traffic 30% of total traffic

Source: Literature search, adapted from "New Generation Wireless Networks" knowledge effort

802.11 Vs 3G Economics For Applications

End-user willingness to pay
$ per MByte

Application	Value
SMS	734.5
iMode data	20.6
Still pictures	5.3
Voice (GSM, 16 Kbps)	2.9
Music (MP3-quality)	0.15
Movies (broadcast-quality)	0.06

Cost of 3G: $.20-.25/MB

- Cost of wireless LAN: $.03-.06/MB
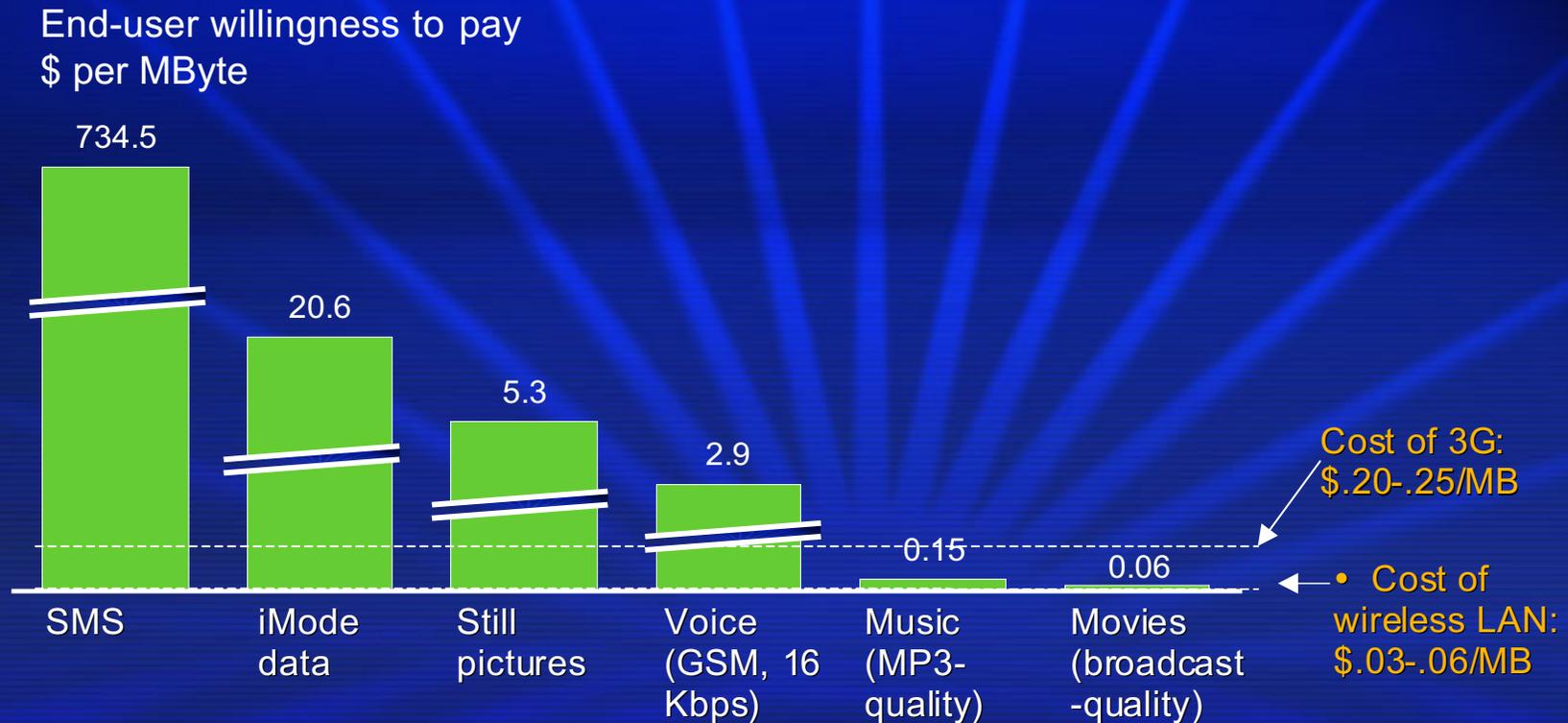
Source: GS Research, Merrill Lynch; McKinsey analysis

Advanced Technologies Relevant to All Approaches

- Smart antennas
  - Beam forming, MIMO
- Mesh networking
- CMOS Radio
- Mobility, Mobile IP
- AAA & Management
- Security

Which one changes the rules of the Industry ?

802.11 x

Drives Demand

802.16

Complementary

Cellular Based

Complementary
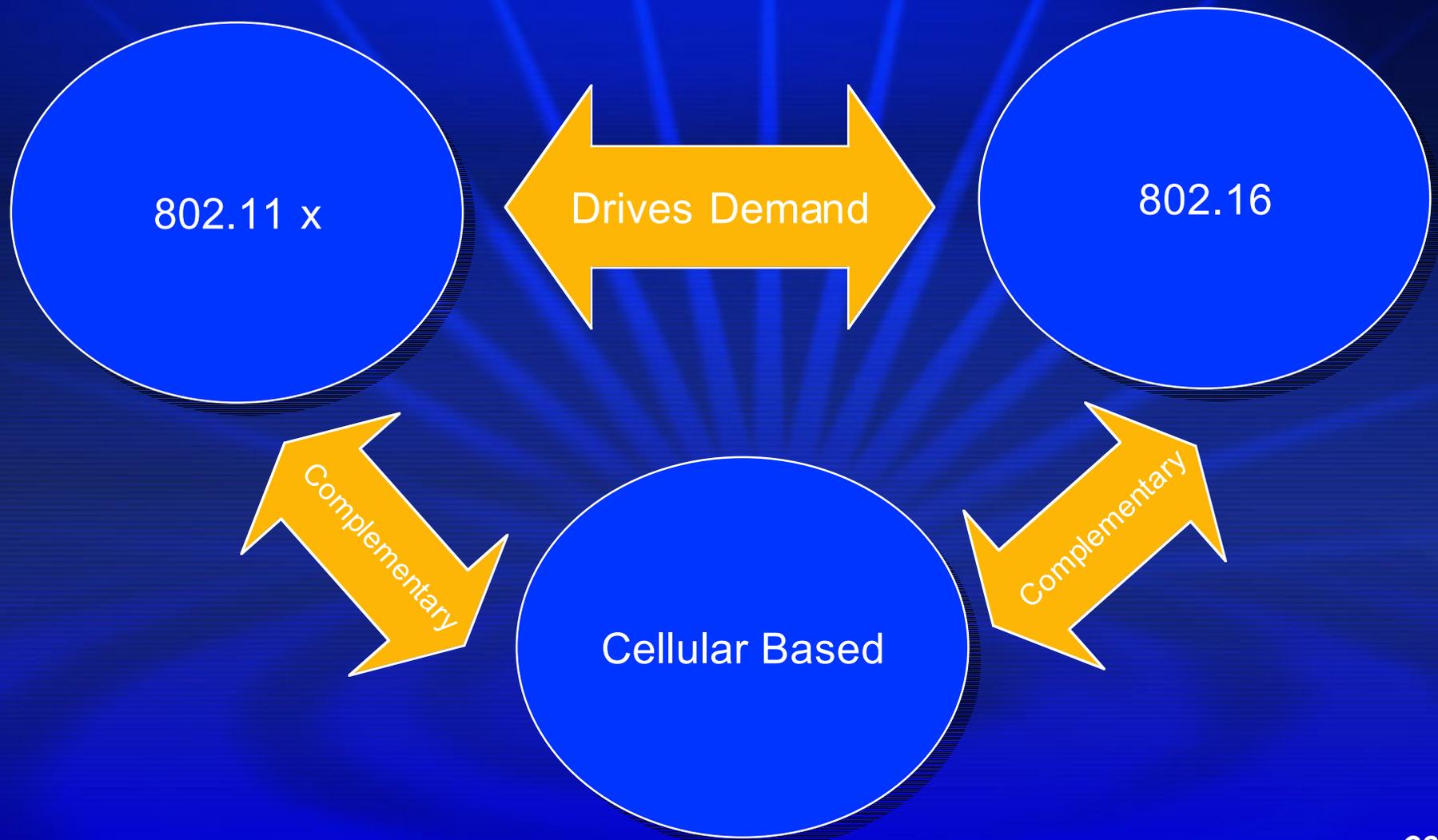
Industry Call to Action

- Deploy rapidly for Last Mile and Hotspots
- Full support of interoperability efforts
  - WiMAX* for 802.16a
  - Wi-Fi Alliance for 802.11
- Solve fundamental technical barriers
  - Security, Roaming, Billing, Range & Coverage for NLOS, Ease-of-Use & Install, etc.
- Influence regulatory framework to harmonize spectrum worldwide
- Drive new usage models (VoIP, home audio/video distribution, …)

Intel Activities

intel.

Intel Mobility & Wireless Vision:

- ## A Mobile Lifestyle …..
  - Powerful flexible devices that deliver great robust experiences
  - Access to data & apps / services anytime, anywhere
 - Simple, secure, seamless connectivity & synchronization

All Communication Devices will Compute	All Computing Devices Will Communicate

"Simply works"

Intel's approach

- Silicon integration
- Chipsets
- Validation
- Standards
- Working groups
- Alliances

Public venues

Silicon Technology And Manufacturing

R&D

Wireless Strategy

Enabling

Investments And Seeds

- Intel research labs
- Research Grants
- Intel Capital
- New Business Investments
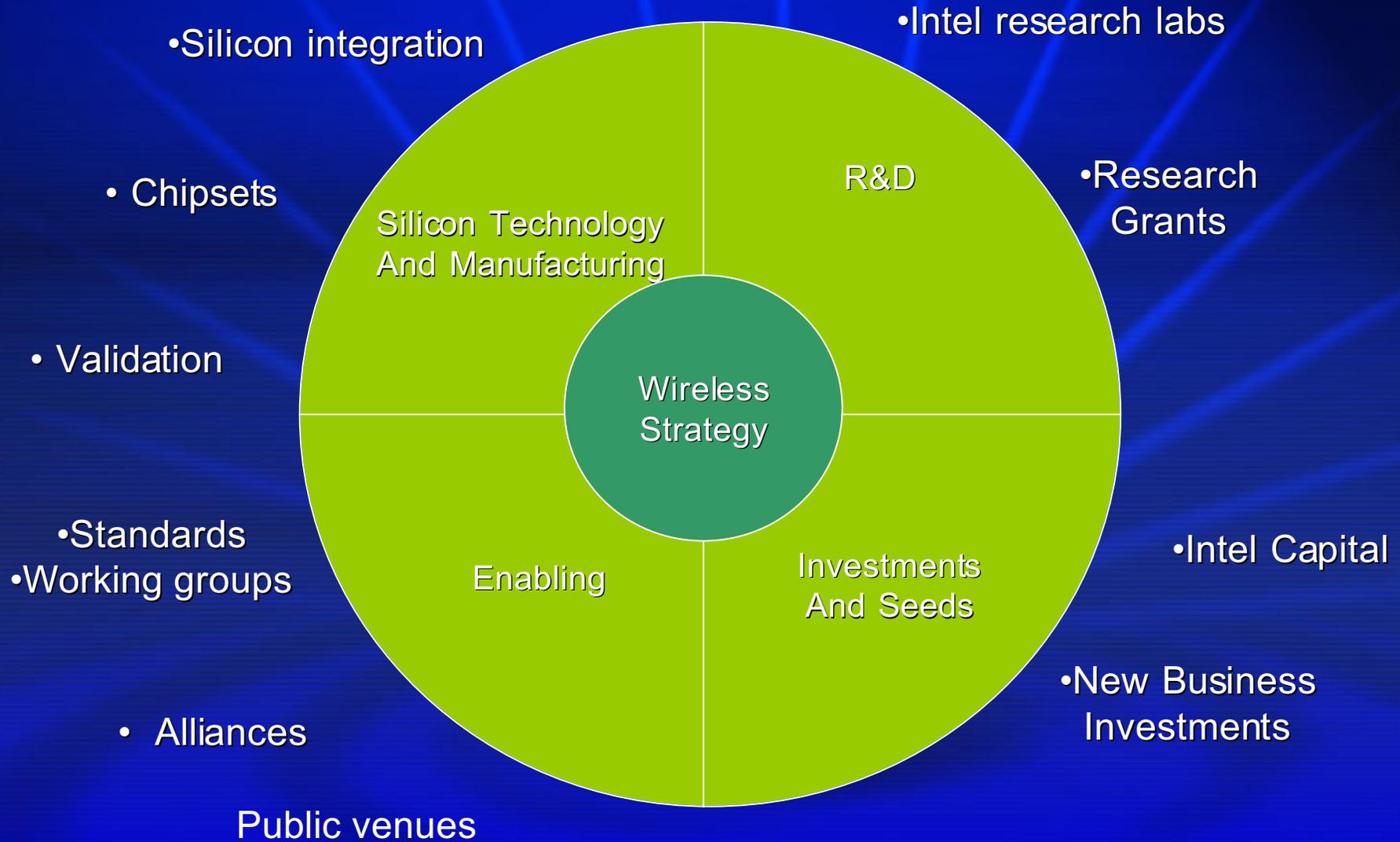
Intel & Industry Groups

- WCA* board member
- 802.11
  - Wi-Fi Alliance* Board Member
  - Chair, 802.11e Task Group – QoS
  - Editor, 802.11i Task Group – Security
  - Editor, 802.11h Task Group – Spectrum & Power Management
  - Active Member, High Throughput Study Group
  - Supporter of WiFi Zone
- 802.16a
  - Joining WiMAX* board – 802.16a Interoperability
  - Active in 802.16e (nomadic)

Wi-Fi Communications Fund

Enterprise	Hotspots	Home

System Architectural View

Ease of Use

Deployment/AP Management Guidelines

Security

Spectrum Harmonization

Range and Throughput Efficiency

QoS

Inter-operator, heterogeneous network roaming & settlement

802.11 Ecosystem Investments

Sample of Investments Supporting 802.11

Summary

- Wireless - A spectrum of opportunities
- 802.11 is first key disruption - 802.16 is Next
- Economics don't work for Broadband data over Cellular
- Interoperability/standards critical

Intel is active in the entire ecosystem !
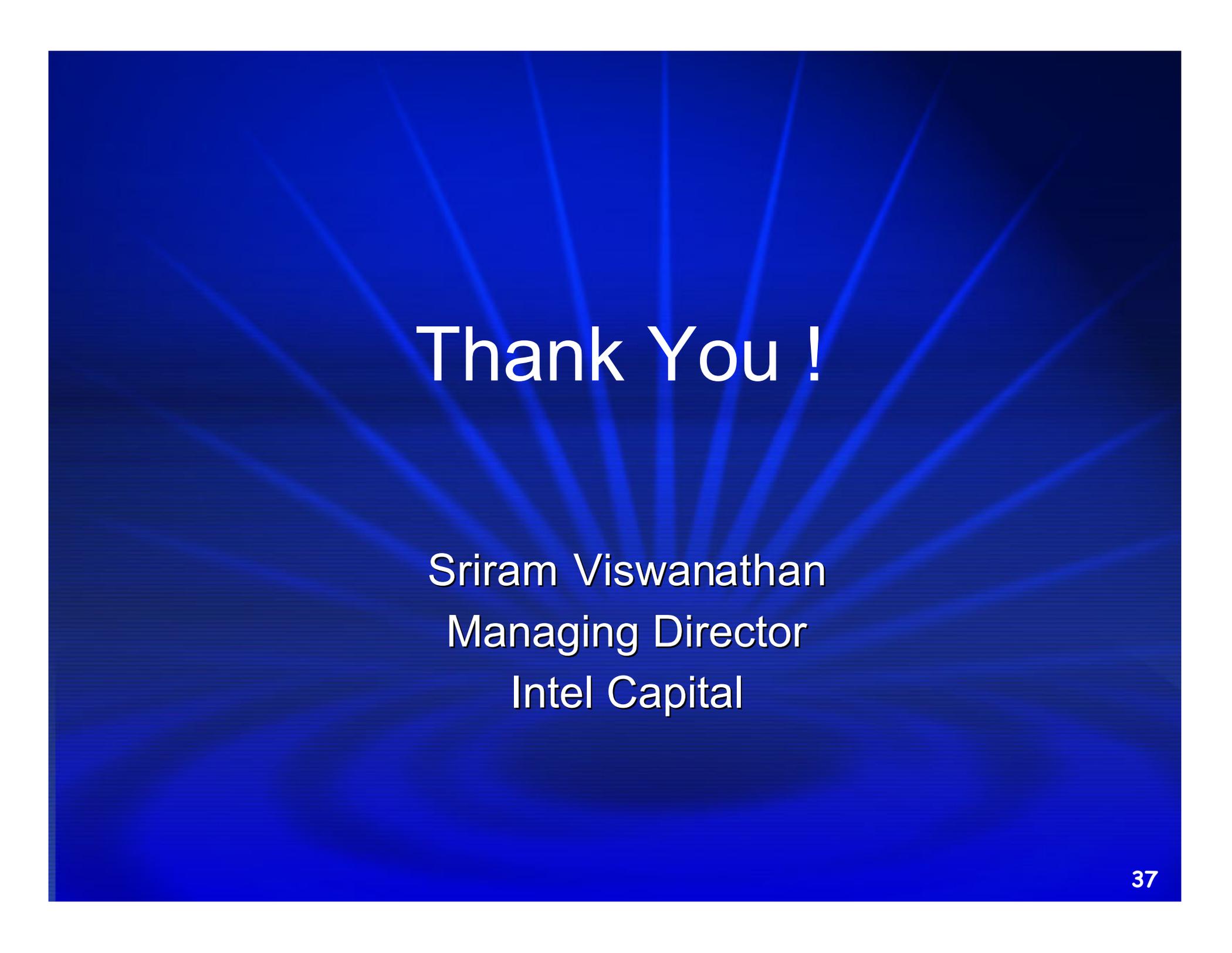
Thank You !

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