



Fiber in smart cities

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Outline

- Smart applications and fiber penetration depth
- Estimation of bandwidth and Number of fibers required per trench (street)





Smart City Applications



Connected cars

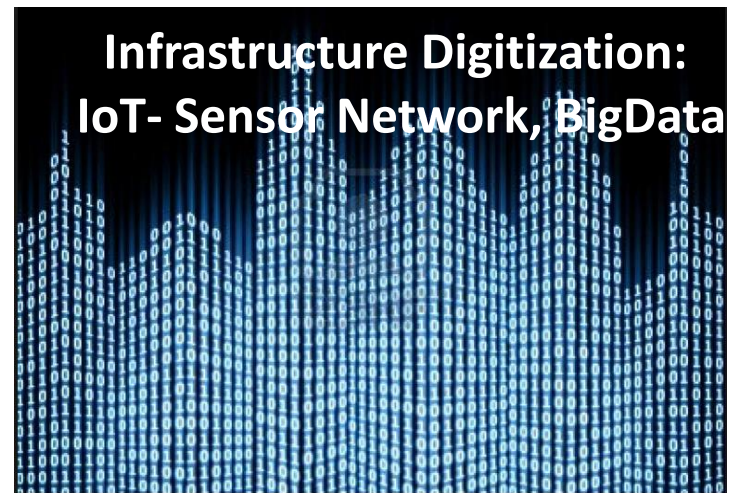
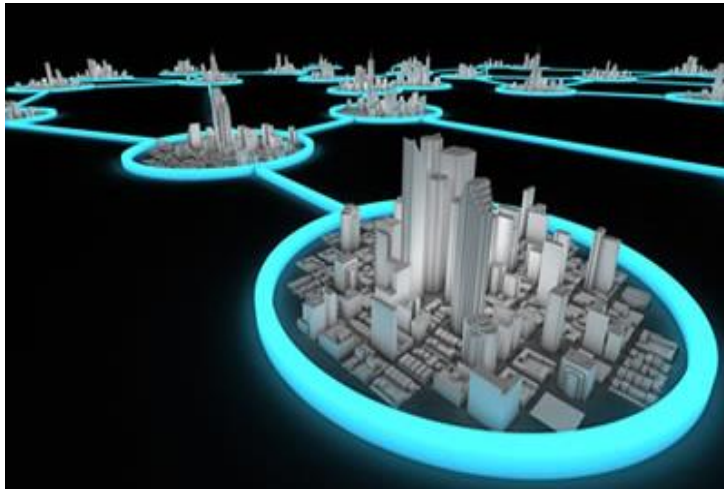
Smart Education



SEE THE LIGHT



Some Others....





Applications & Fiber penetration depth



Ist generation < 500 kb/s

Applications	Bit rates
Audio/Music on demand	128 Kbps
Voice chatting	256 - 512 Kbps
Tele-education	256 - 512 Kbps
Tele-medicine	256 - 512 Kbps
Video-conferencing	384 Kbps

IInd generation: 500 kb/s to 10 Mb/s

Applications	Bit rates
Streaming gaming	800 kb/s
Virtual office	800 kb/s
Video streaming	2 Mb/s
Virtual adhoc network	2 Mb/s
Smart home security	3 Mb/s
Teletraining	4.5 Mb/s
HD video	8 Mb/s
Telesurgery	10 Mb/s

SEE THE LIGHT



Applications & Fiber penetration depth



IIIrd generation: 10 Mb/s to 10 Gb/s

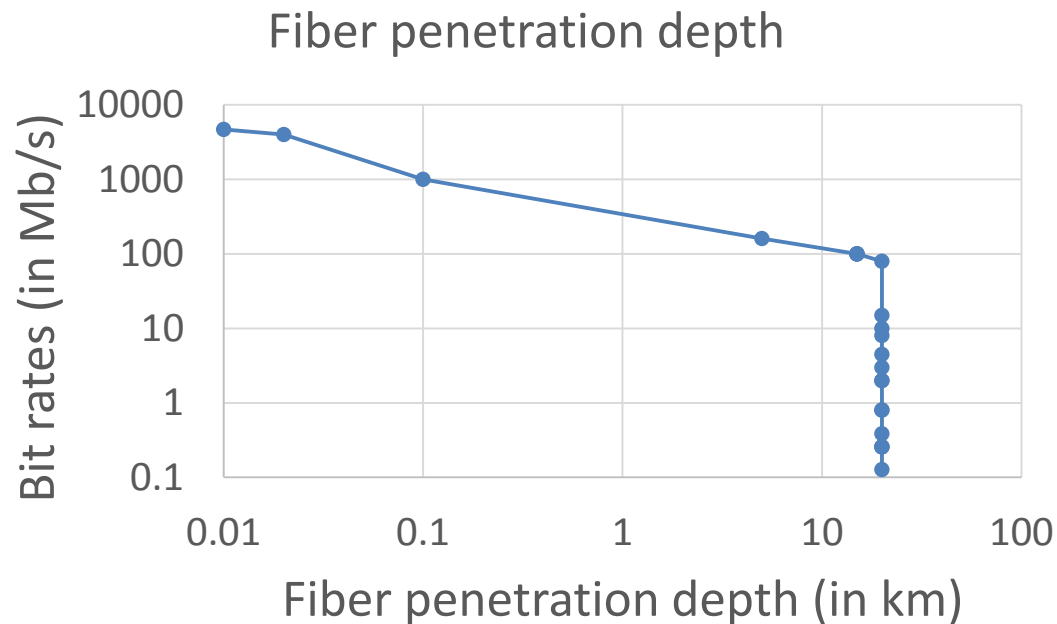
Applications	Bit rates
HD video-conferencing	15 Mb/s
Full motion video	80 Mb/s
HD VoD	100 Mb/s
Smart driving applications	100 Mb/s
Smart manuf. application	100 Mb/s
Wearable technologies	100 Mb/s
8KTV	160 Mb/s

Applications	Bit rates
Telehealth services with IoT sensors	1 Gb/s
3D panorama TV	4 Gb/s
Smart grid applications	4.7 Gb/s
Cloud storage	2x

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Applications & Fiber penetration depth



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Applications and fiber reach

Applications	Data rate	Fiber penetration depth
Smart factory	10 Gb/s	0 m
Smart hospital	10 Gb/s	0 m
Smart future home	5-6 Gb/s	0 m
Smart grid applications	4.7 Gb/s	0 m
Smart home today	1 Gb/s	100 m



Conclusions

- Data rate requirements for smart applications will exceed 1 Gb/s
- For supporting smart city applications, we need a high fiber penetration (less than 100 meters).



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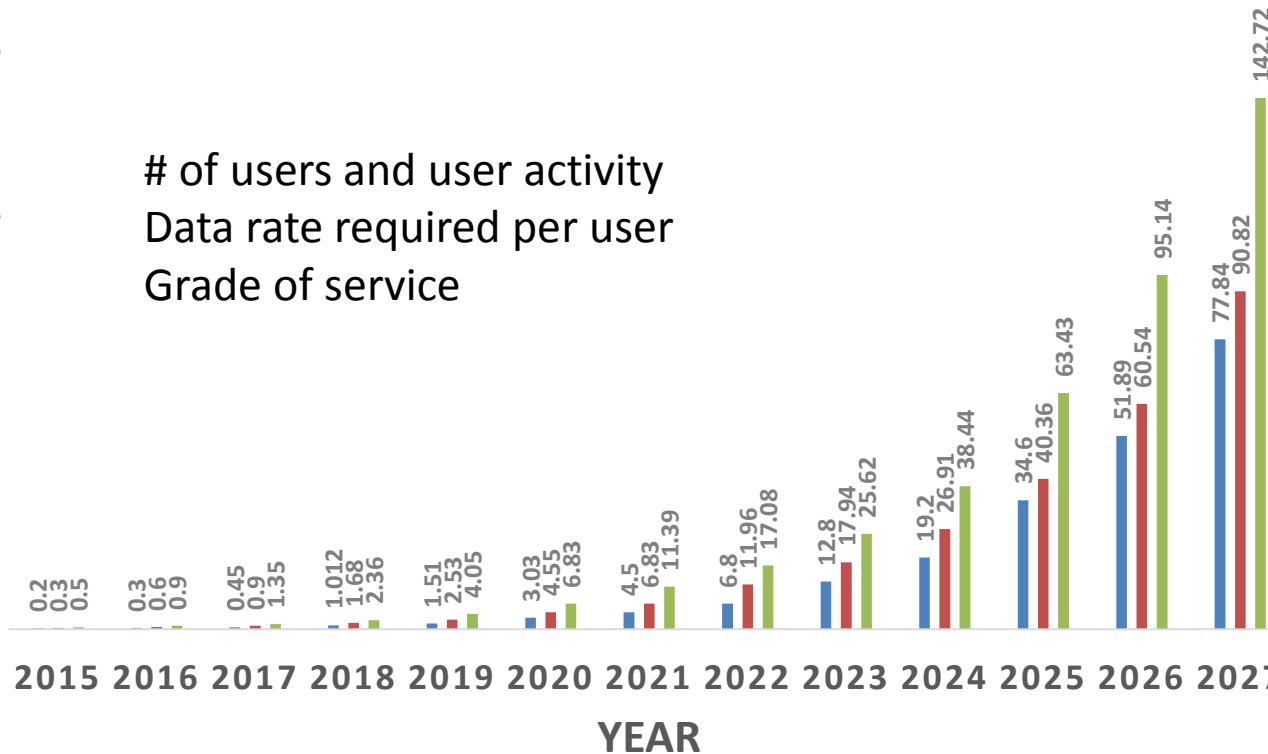
Bandwidth estimation per street

BANDWIDTH REQUIRED

■ Rural ■ Urban ■ Dense rural

LINE RATE PER STREET (IN Gb/S)

of users and user activity
Data rate required per user
Grade of service

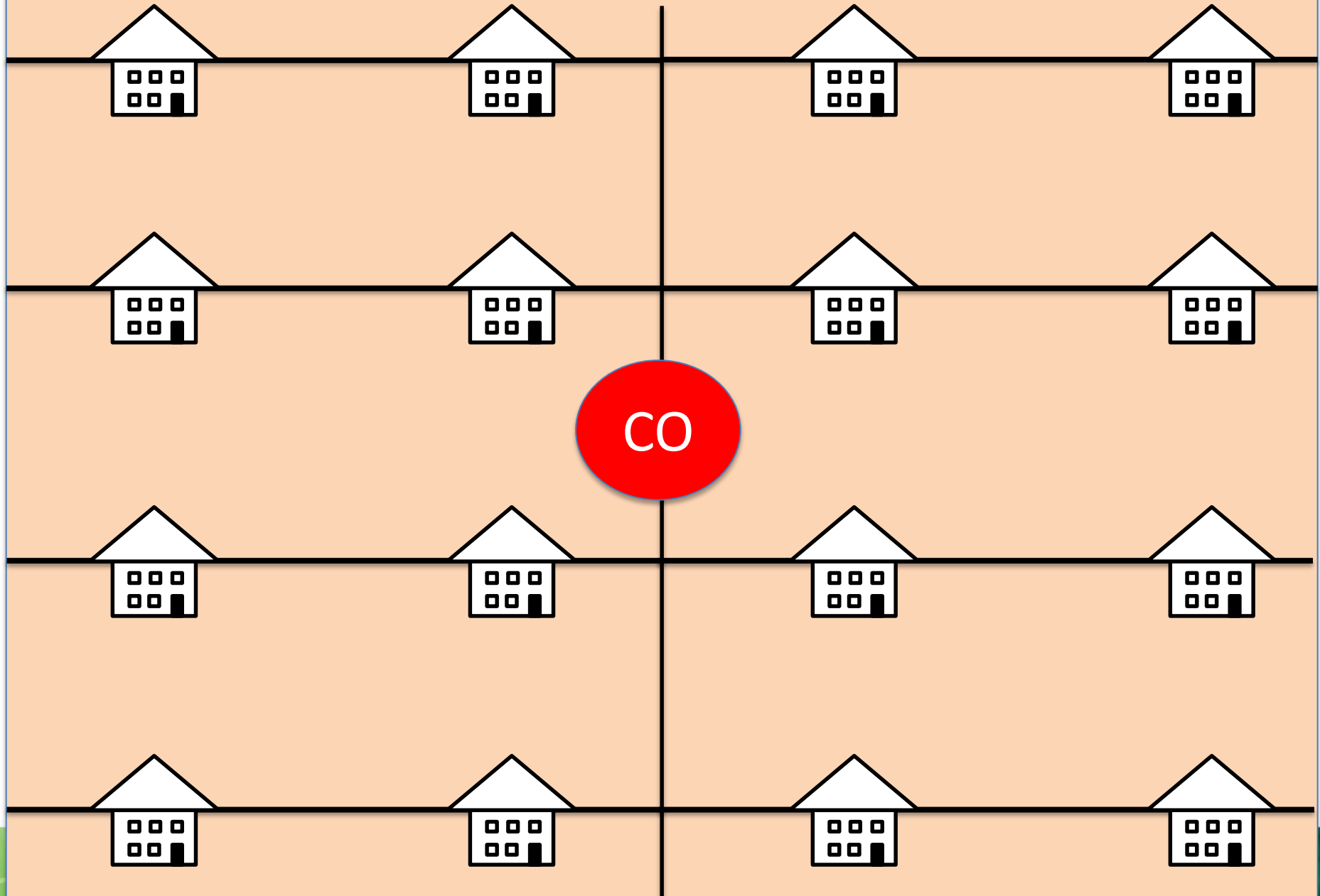




of Fiber per trench (per street)



Considered area & # of houses





Considered scenarios

Scenarios	Dense urban	Urban	Rural
Area (km ²)	5.89	6.51	7.21
Number of buildings	560	470	430
Average number of household per building	7.1	5.3	1.0
Total # of houses	3,976	2,491	430

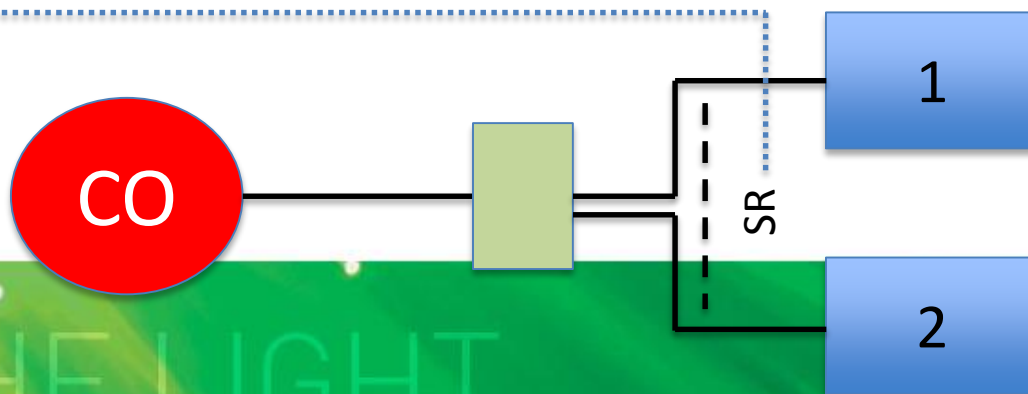


Results



Total fiber length (in km)

Split ratio	1	16	32	64
Dense urban	27773	8129	6611	5851
Urban	20330	5950	4839	4283
Rural	4010	1174	954	845



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Results

Total trench length (in km)

Split ratio	1	16	32	64
Dense urban	137	137	137	137
Urban	139	139	139	139
Rural	145	145	145	145



Results

Total # of fiber

Split ratio	1	16	32	64
Dense urban	242	60	49	43
Urban	174	43	35	31
Rural	33	8	7	6



Conclusions

- By year 2027, bandwidth required per street can rise up to 150 Gb/s
- Trench length is independent of split ratio and depends only on considered geographical area.
- Fiber length decreases exponentially with split ratio.
- We recommend the fiber deployment for a Pt-Pt and dense urban scenario
 - fiber cost is negligible compared to other costs and it presents a most future solution.
 - Per trench, approximately 250 fibers can be used.