Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: Some consideration on KIOSK downloading model of THz communications

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Abstract: Several use models and applications of THz communications have been proposed in the THz Interest Group. In this contribution, we provide some considerations and information which will help to discuss the Technical Exceptions especially for KIOSK downloading models.

Purpose: for discussion

Some consideration on KIOSK downloading model of THz communications

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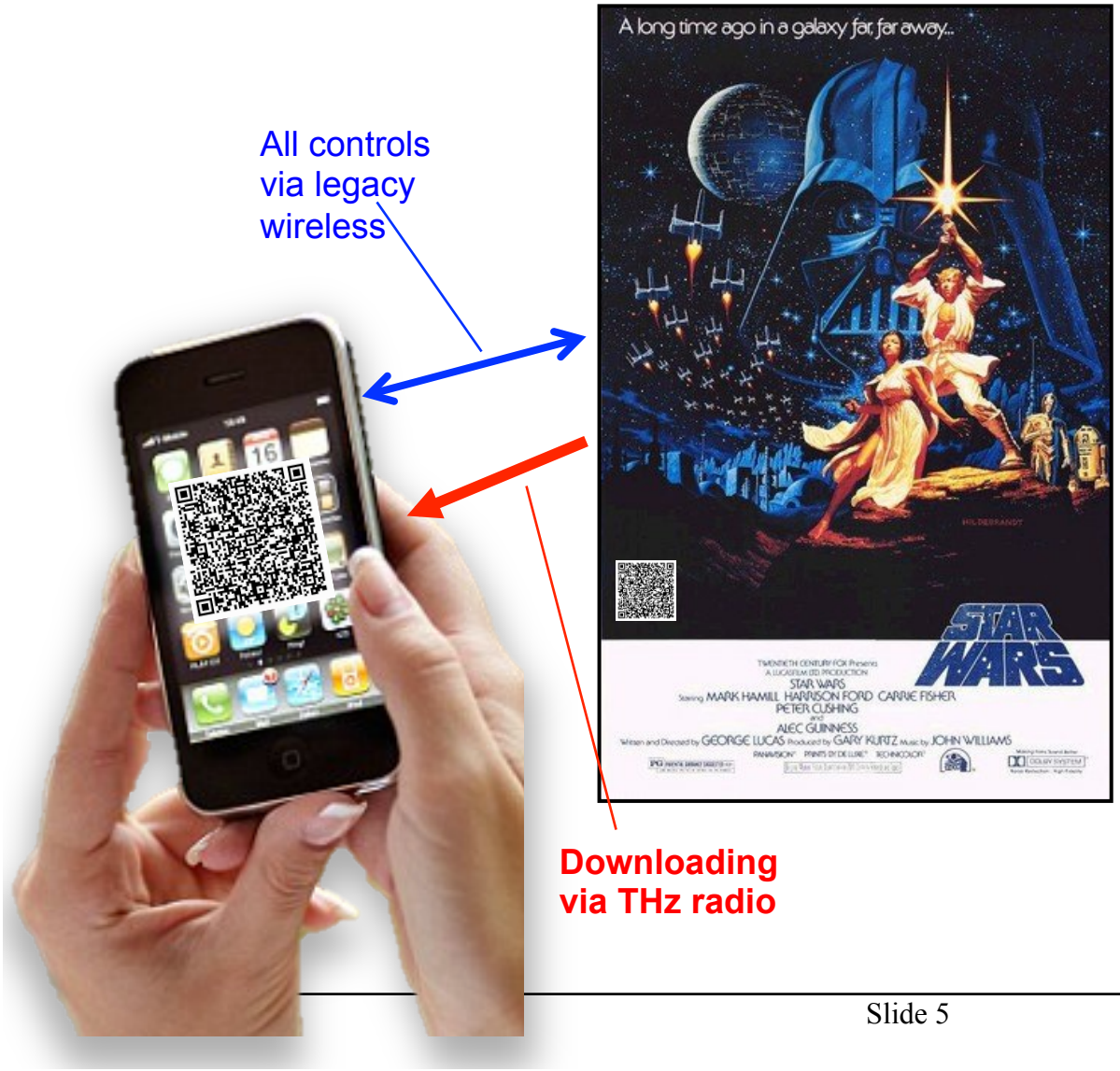
Use Case Vision (1)

- KIOSK Downloading
  - Stationary transmitter
    - relatively free from size and power
    - Maybe connected to fiber-network
    - Or embedded storages as a contents source
  - Mobile receiver
    - Small dimension
    - Low power consumption
  - No more than 1 meter distance

Use Case Vision (2)

- Ad posters in metro/trains or streets can be the front interface for downloading pre-fixed contents such as newly released movies' trailers, full contents of Bru-ray, music CD, books, magazines..

Use Case Vision (3)



Brief scenario

①Rx Reads a ***QR code*** including network configuration for downloading as well as other information

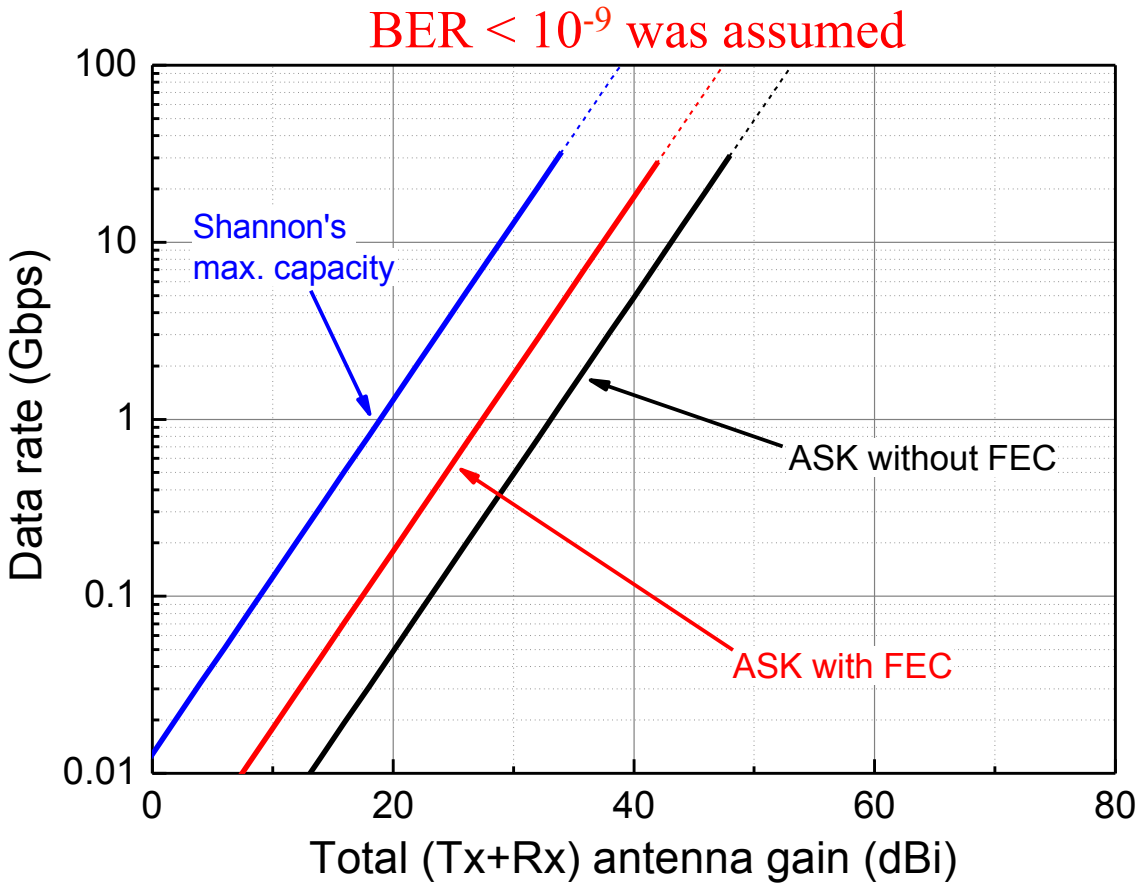
②Rx sends Request To Open Session via legacy wireless, eg. Bluetooth.

③All other communications (security, payment) conducts via the legacy, except downloading data.

④Tx sends data via THz-radio.

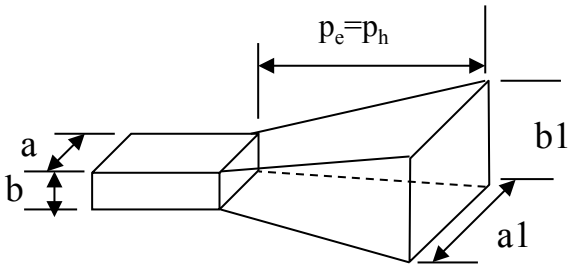
Link Budget

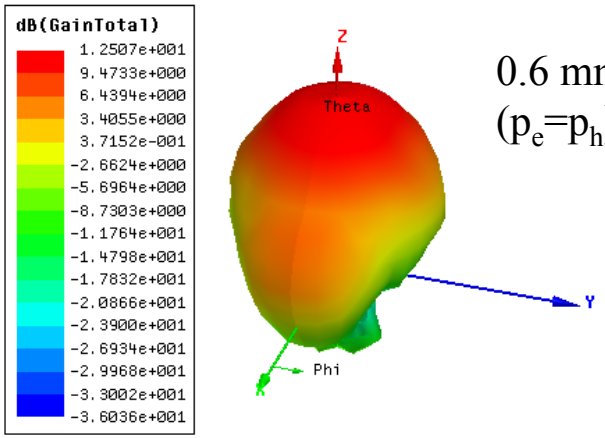
Quantity	Sym bol	Value
Transmitting power	P_t	**10 dBm**
Carrier frequency	f_c	300 GHz
Wavelength	λ_c	1 mm
Distance	d	**1 meter**
Atmospheric attenuation	α-$_a$	0.1 dB/m @ f_c
Noise spectral density	N_0	-178 dBm/Hz
Spectral efficiency		1 bps/Hz
Noise bandwidth	B	Data rate × spectral efficiency
Total noise figure	**NF**	**15 dB**
System margin	M	10 dB



- For 20 Gbps, Tx/Rx antennas together should provide more than 46-dBi gain

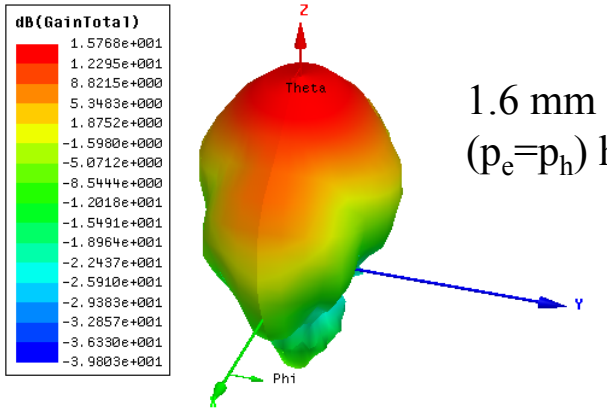
Antennas for Rx





0.6 mm long (p_e=p_h) horn

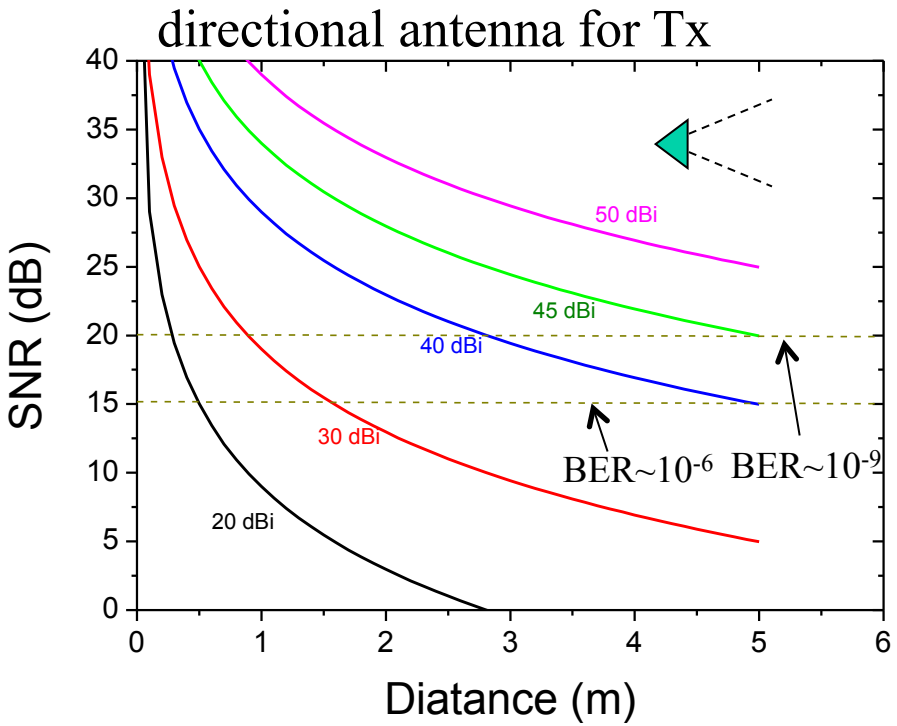
- Standard Horn antenna for reference (@ 300GHz),
  - ✓ >12dBi with 0.6 mm long (p_e=p_h) horn
  - ✓ >15 dBi with 1.6 mm long



1.6 mm long (p_e=p_h) horn

12~16 dBi gain antenna would be available in a couple of millimeter thick dimension.

Antenna for Tx (1)



Calculation parameters

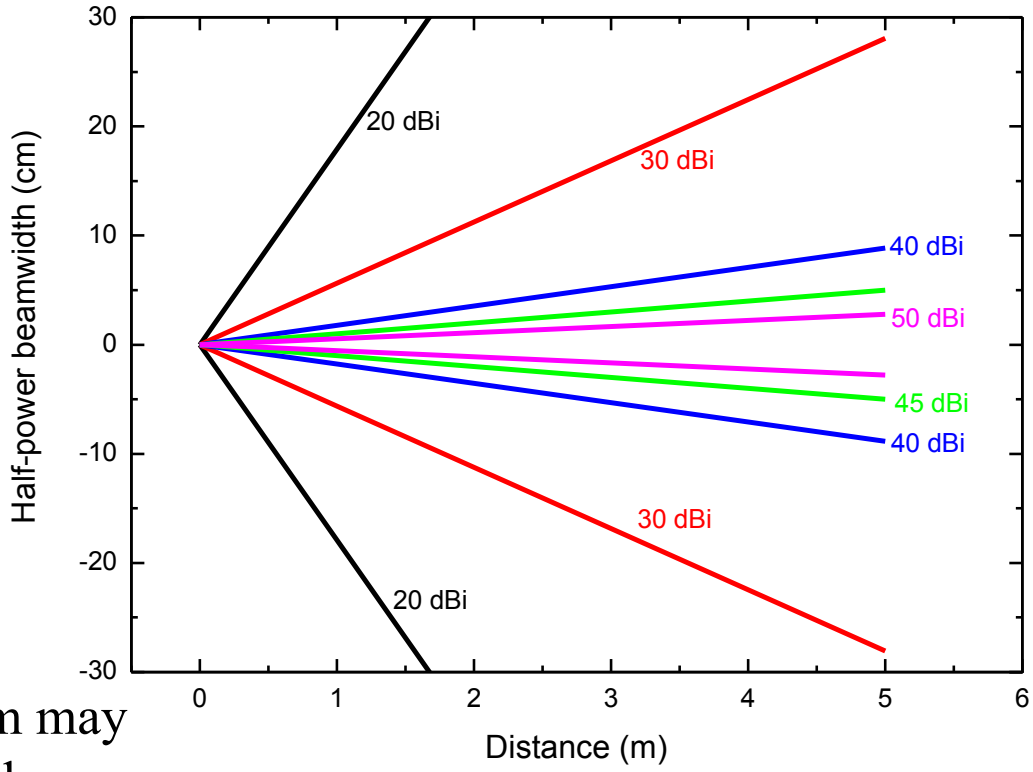
- @ 300 GHz
- P_{TX} = 10 dBm
- NF_{RX} = 15 dB
- Margin = 10 dB
- $AntennaGain_{Rx}$=15 dB
- Bandwidth = 30 GHz for 20-Gbps

If we have 15-dBi Rx antenna, Tx antenna have to provide 30-dBi gain for BER $< 10^{-9}$

Antenna for Tx (2)

	Dia. of Aperture (cm)*	Angle (deg)	Beamwidth (cm)		
			0.1 m	1 m	5 m
20 dBi	0.32	20.3	3.6	35.8	179.1
30 dBi	1.0	6.4	1.1	11.2	56.1
40 dBi	3.2	2.0	0.35	3.5	17.7
45 dBi	5.7	1.1	0.2	2.0	10.0
50 dBi	10.0	0.64	0.11	1.1	5.6

*) assumed symmetric circle shape ($A=\pi r^2$)

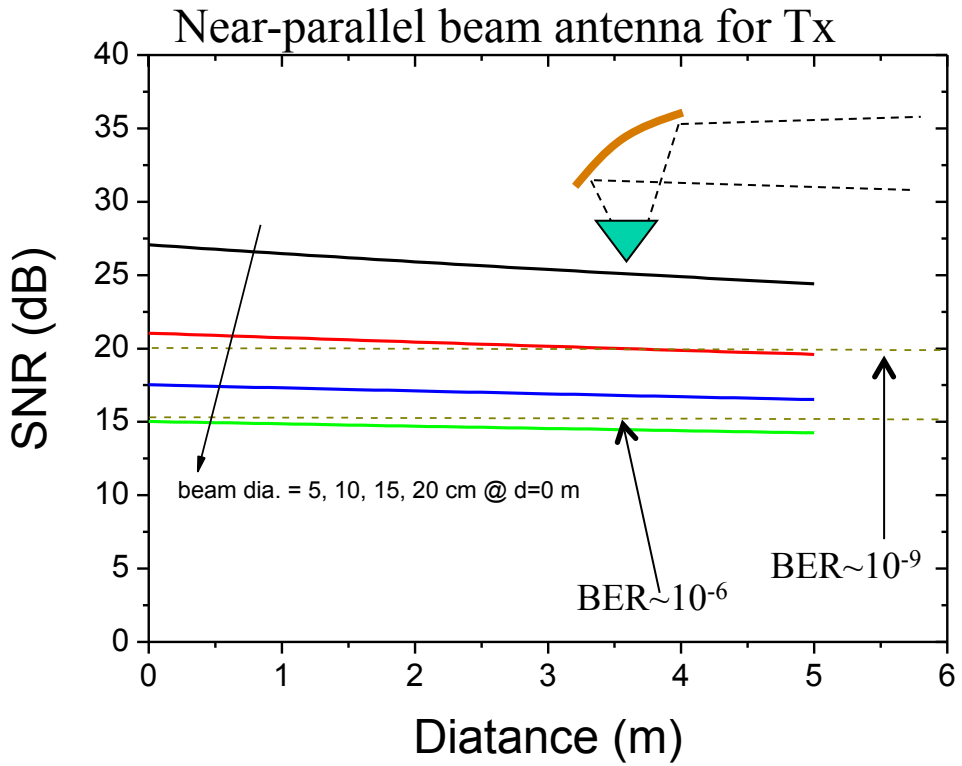


- Coverage or beam alignment problem may occur in very short distance, especially with a hand-held mobile receiver
- Because of beamwidth issue, antenna gain for Tx or min. link distance should be limited.

$$\Theta_{E,H} = \frac{4\pi}{D_a}$$

where, D: directivity (= G_a)

Antenna for Tx (3)



Near-parallel beam antenna will help to make the link more tolerant to the beam alignment even with no automatic beam streering.

Data rate vs. download time

Running time of 1080p24 video(*)	Size	Time for downloading (sec)		
		10 Gbps	40Gbps	100 Gbps
5 min	1.5 GByte	1.2	0.3	0.12
30 min	9.0 Gbyte	7.2	1.8	0.72
2 hours	36 Gbyte	28.8	7.2	2.88

(*)1080p24 video runs at up to 40-Mbps rate (source: Wikipedia)

Data rate vs. People

The New York Times

February 29, 2012

For Impatient Web Users, an Eye Blink Is Just Too Long to Wait

By STEVE LOHR

Wait a second.

No, that's too long.

Remember when you were willing to wait a few seconds for a computer to respond to a click on a Web site or a tap on a keyboard? These days, even 400 milliseconds — literally the blink of an eye — is too long, as Google engineers have discovered. That barely perceptible delay causes people to search less.

"Subconsciously, you don't like to wait," said Arvind Jain, a Google engineer who is the

People will visit a Web site less often if it is slower than a close competitor by more than 250 milliseconds

highlights, news updates or recommendations for nearby restaurants. The competition to be the quickest is fierce.

People will visit a Web site less often if it is slower than a close competitor by more than 250 milliseconds (a millisecond is a thousandth of a second).

"Two hundred fifty milliseconds, either slower or faster, is close to the magic number now for competitive advantage on the Web," said Harry Shum, a computer scientist and speed

http://www.nytimes.com/2012/03/01/technology/impatient-web-users-flee-slow-loading-sites.html?sq=second%20web&st=nyt&scp=1&pagewanted=print

Data rate vs. Bandwidth

- According to many technical articles, more than 10-% bandwidth of power amplifier seems challenging.

- Let say, we have 30 GHz at 300 GHz.
  - ✓ 30 Gbps with ASK/BPSK max.
  - ✓ 60 Gbps with QPSK max.

Data rate vs. download time

Running time of 1080p24 video(*)	Size	Time for downloading (sec)		
		30 Gbps	60Gbps	100 Gbps
5 min	1.5 GByte	0.4	0.2	0.12
30 min	9.0 Gbyte	2.6	1.3	0.72
2 hours	36 Gbyte	9.6 ???	4.8	2.88

(*)1080p24 video runs at up to 40-Mbps rate (source: Wikipedia)

Power Consumption

- RF Front end may not impact on battery because of very short active time.
  - ✓ 1-Watt consumption at 3.3 V supply
    - Downloading for 10 sec requires 303 mA x 10 sec ~ 0.84 mA·Hour (iPhone4S battery ~ 2100 mA·Hour)
- With Tx having PA with 5% PAE
  - ✓ For 10 mW output power, 200 mW consumption.
  - ✓ 340 GHz PA presented in technical article offered more than 7% PAE.
- From our experience, RF radio-front for ASK receiver for upto 20Gbps (antenna, 300-GHz pre-amplifier, detector, output data amplifier) can operate with less than 100 mA at 3.3 V.

Summary

- Rx Antenna: Available antenna gain with a couple of millimeter dimension would be up to 15-dBi.
- Tx Antenna: Near parallel beam antenna may have to be considered in order to expand coverage area at very short distance in KISOK use model.
- Data rate (Download time, Powers, People) vs. Bandwidth → *as high as BW allows*
- Very high data rate makes the THz radio not impacting on battery.

Thank you for your attention