LMDS TRIAL RESULTS

KEPPEL COMMUNICATIONS PTE LTD

TRIAL OBJECTIVES

The trial was organized in 2 parts with the following objectives:

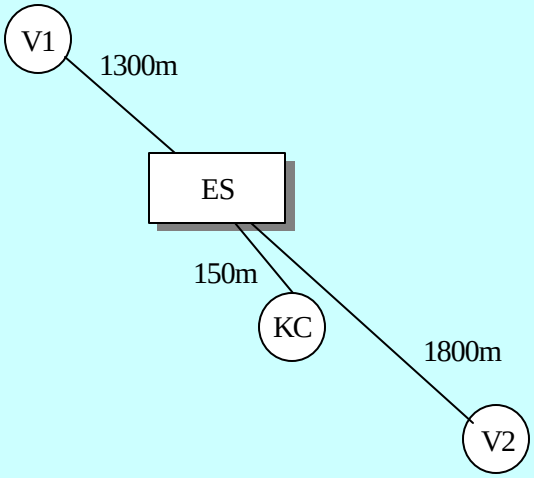
Part I -

To explore the entire spectrum of real life technical and business issues to be encountered in LMDS rollout with the strategic vendor partners on a purpose built platform, in order to beef up KC's core competence and resource buildup in support of any network service providers for their commercial deployments.

Part II -

To validate the technological , product and service readiness of LMDS with the trial partners on behalf of the interests of potential service providers and business/consumer subscribers.

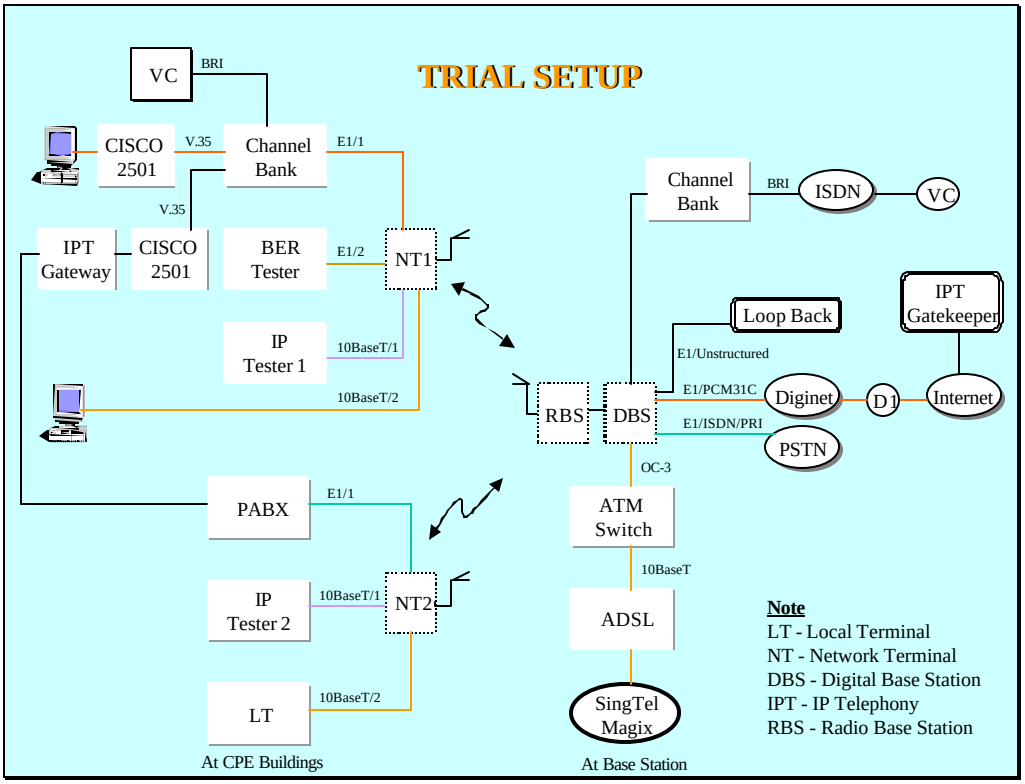
LMDS TRIAL SITES IN TAMPINES LOCATION



Note
KC - Keppel Communications
ES - East Gate
Venue 1 - V1
Venue 2 -V2

LOCATION DATA

Building	Type	Antenna Height	GPS Readings
KC	CPE	200 ft	N 1° 20.343' E 103° 56.709'
EG	Base Station	250 ft	N 1° 20.413' E 103° 56.674'
V1	CPE	100 ft	N 1° 20.720' E 103° 55.952'
V2	CPE	90 ft	N 1° 19.857' E 103° 57.645'



SYSTEM CONFIGURATIONS

	Vendor A	**Vendor B**	**Vendor C**	**Vendor D**
Trial Frequencies *Up stream *Down stream	 27.5 – 27.68 GHz 28.0 – 28.18 GHz	 24.63 – 24.65 GHz 25.23 – 25.25 GHz	 27.5 – 27.68 GHz 28.0 – 28.18 GHZ	 28.0 – 28.18 GHz 28.0 – 28.18 GHz
Shared Radio Access *Up stream *Down stream	 TDMA/FDMA TDM	 FDMA TDM	 TDMA TDM	 TDMA TDM
- Airlink Duplexing - Modulation Type	FDD QPSK/D-QPSL	FDD QAM 4/16/64	FDD QPSK	TDD QAM 4/16/64
Bandwidth per Channel *Up stream *Down stream	 07 MHz 28 MHz	 5.2 – 6.0 MHz 10 – 11.5 MHz	 09 MHz 36 MHz	 8.3 MHz 8.3 MHz
Data throughput per Channel *Up stream *Down stream	 8.38 Mbps 32.38 Mbps	 4.6 – 5.2 Msymbols per sec 8.7 Msymbols per sec	 10.02 Mbps 41.68 Mbps	 6.888 Msymbols per sec 6.888 Msymbols per sec
Antenna Polarization	Co-polarized	Co-polarized	Cross	Co-polarized

PART I

SPECIFIC OBJECTIVE

To identify, simulate, evaluate and resolve (if needed) the perceived bottlenecks in LMDS rollout with a practice-oriented generic test bed.

SCOPE OF WORK - CONNECTIVITY

- PSTN
- DIGINET
- ISDN
- SINGTEL MAGIX

SCOPE OF WORK - SERVICES

- Digital Telephony
- IP Telephony
- Virtual Private Network
- Internet Access
- ATM Transport
- Lease Circuit
- Frame Relay

SCOPE OF WORK - APPLICATIONS

- Voice
- VOIP
- Fast Internet Access
- Video Streaming
- Narrow Band Video Conferencing
- Broad Band Video Conferencing
- High Speed File Transfer
- Web Hosting
- IP TV

ADDRESSED ISSUES - TECHNOLOGY

- Transport Technology
- Channel Access Technology
- RF Modulation
- Traffic Switching/Routing Technique
- Data Protection Technique
- Frequency Stability and Clock Synchronization

ADDRESSED ISSUES - ENGINEERING

- Building Selection and Access
- Infrastructure Design Considerations
- Interface to Fix-line Infrastructure
- Co-location
- Antenna Layout and Alignment
- Network Resource Planning
- Channel Characterization

ADDRESSED ISSUES - BUSINESS

- Financial Attributes
- Quality of Service
- Class of Service
- Business Strategy
- Business Plan

PART II

SPECIFIC OBJECTIVES

The trial conducted by Keppel Comms in collaboration with the trial partners on different leading vendors' platforms was designed to provide an overall assessment of LMDS performance pertaining to:

- Field reliability of the equipment and system;
- Connectability and delivery quality of key infocom services; and
- Rain fade effect on CBR and IP traffics

GENERAL DESCRIPTIONS

- Base station location	East Gate Building
- CPE location for Quantitative Data Collection	
*Building	Keppel Comms Bldg.
*Distance to base station	150m
*Height difference	50ft
- Rain fade margin	25 - 30 dB
- E1 interface to wired network	G.703
- Video streaming quality	512Kbps 2p video
- BER tester resolution	up to 10Exp (-10)
- IP testing protocol	FTP
- Video conferencing quality	128Kbps
- VOIP standard	H.323

TEST PROCEDURES - FIELD RELIABILITY

The trial setup as depicted would be kept running continuously upon commissioning.

Any equipment malfunctioning or system inserviceability would be archived.

Direct causes as well as peripheral factors like power stability, clock synchronization with the fixed line network and climatical impacts are tracked for reasoning the surfaced effects.

TEST PROCEDURES - CONNECTABILITY AND QUALITY OF SERVICE

	Video Streaming	Telephony	Fast Internet Access/VOIP	Remote LT Access
Source	ADSL link connected to SingaporeOne with access to video content in IP at 512Kbps	ISDN/PRI with 30 voice channels connected to E1 port of DBS	A structured PCM31C lease circuit connecting an E1 port of the DBS to the Bay Network access router of an ISP - D1	ATM port of LT
Access Terminal	PC connected to 10 BaseT Port of NT	In-house PABX extensions with DDI facility	Routers connected to the E1/1 port of NT1 via V.35 interface of the channel bank provide PCs and VOIP Gateway access to the internet	Accessible at NT2 via ATM switch
Test Attributes	Subjective video quality, picture stability and frame continuity	Service availability, voice quality and speed of connectivity	Link availability, access speed and VOIP quality	Link Availability
Test Group	1 PC to each NT	A total of 20 participants representing typical office telephone usage pattern	4 VOIP extensions; VOIP and internet access to all in-house users	One NT4 workstation at CPE
Approach	Random Access	Continuous link but random access	Continuous link, subjective and random evaluation	Continuous link

TEST PROCEDURES - RAIN FADE EFFECT

	CBR Traffic	IP Traffic
Test Channel	A loopback E1 channel between Base Station and CPE	A 10 BaseT link between NT1 and NT2
Test Tool	BER Tester	Proprietary IP test tool
Test Attributes	BER, pattern synchronization and link availability	FTP transfer duration
Test Approach	Quantitative and continuous	Quantitative, fixed interval file transfer
Peripheral Data	Weather data, PABX connectivity	Weather data, Internet accessibility

TEST RESULTS - FIELD RELIABILITY

	Equipment	System
Data collection begin	22/8/00	22/8/00
Total Test Hour	Over 2000 hours	Over 1700 hours
Serviceability	100%	99.97%
Issues	NIL	- In a few incidents, NTs detected no signals during fine weather, which caused NTs to reset. - Less than 10 seconds to resume link but up to 90 seconds for channel to stabilize after reset of NTs

TRIAL RESULTS - CONNECTABILITY AND QUALITY OF SERVICE

	Video Streaming	Telephony	Fast Internet/VOIP	Remote LT Access
Connectability	Yes	Yes	No, perhaps, because of incompatible DSUs used	Yes
Quality against fixed line service	No difference	Acceptable	-	No difference
Connection time	No difference	Slightly longer	-	Reasonably fast because of bandwidth availability and priority setting
Service Reliability	Little effect with rain	Little effect with rain	-	Need to reset whenever RF link is down
Issues	NIL	Higher residual BER because of frame jittering resulted in frequent need for D-channel reset, if the fix-line infrastructure not properly installed	-	At least once, link restoration required power reset at base station with the current version of software

*After note - KC has only got this link connected successfully very recently, after correctly addressing all the issues including clocking, framing, device configuration, service subscription and interface definition with the trial equipment vendors and fix-line service providers.

TEST RESULTS - RAIN FADE EFFECTS

Rain Intensity	CBR Traffic (BER)	IP Traffic (Percentage of usable Bandwidth)
0 – 30	0	100%
30 – 50	0	Higher than 90%
50 – 100	Better than 10 Exp(- 10)	Higher than 80%
100 – 150	Better than 10 Exp(-9)	Higher than 75%
Greater than 150	Better than 10 Exp(-6)	About 30%

THE ASSESSMENTS (1/1)

LMDS equipment are production ready as exhibited by their excellent field reliability in the trial.

The link availability is believed to be better than the 99.97% measured after discounting the possible impacts by power disruption and cable re-routing as a result of the frequent renovation work done at the CPE and base station buildings during the data capturing.

Although the network stability was tarnished by a few occasions of link disconnection in fine weather, the good thing is the links were able to be restored by the systems within seconds. Given that the trial equipment are in either their first or early second generation, there is good possibility that the issue would be resolved with the future upgrades.

THE ASSESSMENTS (1/2)

In the context of the trial environment, LMDS seems to be far less sensitive to rain fade than expected. In practical sense, the CBR traffics like telephony were virtually unaffected, while the less prioritized IP traffic have only experienced slower throughputs depending on the rain intensity because of higher BER on the link.

The teething issues were in fact not the inherent quality and reliability of the LMDS solutions, but rather the interfaceability and the delivery quality of the fix-line services, which have always been taken for granted.

CONCLUSIONS

As the trial result have indicated, LMDS is a ready and viable broadband access technology for deployment

However, given the host of interfacibility and peripheral issues encountered during the trial, a customer satisfied and reliable rollout of LMDS is only guaranteed through a strong partnership between proven equipment vendors and experienced system integrators.

Unlike their fix-line counterparts, LMDS service providers have to face additional challenge to develop their product offerings and pricing strategy basing on weather sensitive, dynamic network bandwidth capacity. Therefore, extensive field engineering databases and powerful network design tools are also found to be equally important for the business ventures.