

Contents

| | |
|---|------|
| Special Report Notice Of Disclaimer | iii |
| List of Figures | ix |
| List of Tables | x |
| Foreword | xi |
| 1. Introduction | 1-1 |
| 1.1 Purpose and Scope | 1-1 |
| 1.2 Structure of This Document | 1-2 |
| 2. Fiber In The Loop (FITL) Overview | 2-1 |
| 2.1 Overview of Outside Plant and Copper-Based Systems | 2-1 |
| 2.2 What is Fiber In The Loop (FITL)? | 2-4 |
| 3. FITL Unbundling and Collocation | 3-1 |
| 3.1 Competition in the Market Place | 3-1 |
| 3.2 Unbundling | 3-2 |
| 3.3 Collocation and Line Sharing | 3-3 |
| 3.4 Impact of Unbundling and Collocation Issues on FITL | 3-4 |
| 4. FITL Basics | 4-1 |
| 4.1 Technology Overview | 4-1 |
| 4.2 Functional Components | 4-2 |
| 4.2.1 Optical Line Termination (OLT) | 4-2 |
| 4.2.2 Optical Distribution Network (ODN) | 4-4 |
| 4.2.2.1 ODN Topology | 4-4 |
| 4.2.2.2 ODN Components | 4-6 |
| 4.2.2.3 ODN Parameters | 4-8 |
| 4.2.2.4 ODN Powering | 4-11 |
| 4.2.3 Optical Network Unit (ONU) | 4-11 |
| 4.2.4 Network Interface Unit (NIU) | 4-13 |
| 4.3 Basic FITL System Architectures and Models | 4-15 |
| 4.4 Service Capabilities of FITL | 4-18 |
| 4.4.1 Analog Voice | 4-19 |
| 4.4.1.1 Customer Premise | 4-20 |
| 4.4.1.2 FITL Access System | 4-20 |
| 4.4.1.3 Backbone Network and the Public Network | 4-21 |
| 4.4.2 Video | 4-21 |
| 4.4.2.1 Customer Premise | 4-22 |
| 4.4.2.2 FITL Access System | 4-22 |
| 4.4.2.3 Backbone Network | 4-24 |
| 4.4.2.4 Video Information Providers (VIPs) | 4-24 |
| 4.4.3 Data | 4-25 |
| 4.4.3.1 Customer Premise | 4-27 |
| 4.4.3.2 FITL Access System | 4-27 |
| 4.4.3.3 Backbone Network | 4-28 |
| 4.4.3.4 Internet Service Provider (ISP) | 4-28 |

- 4.4.3.5 Public Internet 4-29
- 4.4.4 Voice over Packet (VoPacket) 4-29
 - 4.4.4.1 Customer Premise 4-30
 - 4.4.4.2 FITL Access System 4-31
 - 4.4.4.3 Backbone Network 4-31
- 4.5 Integration with Other Technologies 4-31
 - 4.5.1 ATM 4-32
 - 4.5.2 IP 4-32
 - 4.5.3 SONET 4-33
 - 4.5.4 DWDM 4-33
- 4.6 Relation to Digital Loop Carrier (DLC) 4-34
 - 4.6.1 Integrated FITL System 4-34
 - 4.6.2 Universal FITL System 4-35
- 4.7 Standards Initiatives 4-36
 - 4.7.1 Full Service Access Network (FSAN) 4-37
 - 4.7.2 10 Gigabit Ethernet Alliance 4-37
 - 4.7.3 Ethernet in the First Mile IEEE 802.3 Study Group 4-37
 - 4.7.4 Resilient Packet Ring (RPR) Alliance 4-38
- 5. Fiber To The Curb (FTTC) and Fiber To The Node (FTTN) 5-1
 - 5.1 Overview 5-1
 - 5.2 Drop Technologies 5-2
 - 5.2.1 Twisted Copper Pair 5-2
 - 5.2.2 Coaxial Cable 5-2
 - 5.2.3 Broadband Fixed Wireless Access (BFWA) 5-3
 - 5.3 Architectural Options 5-4
 - 5.3.1 Hybrid Fiber Coaxial (HFC) 5-4
 - 5.3.1.1 Architectural Overview 5-4
 - 5.3.1.2 System Characteristics 5-6
 - 5.3.1.3 Advantages 5-7
 - 5.3.1.4 Limitation and Implementation Issues 5-7
 - 5.3.2 Developing Architectures - The Passive Optical Network (PON) 5-8
 - 5.3.2.1 ATM PON (APON) 5-9
 - 5.3.2.2 Ethernet PON (EPON) 5-9
 - 5.3.3 Developing Architectures - Enhanced SONET and Other Ring Technologies 5-10
 - 5.3.3.1 Resilient Packet Ring (RPR) 5-11
 - 5.3.3.2 Multi-Service Provisioning Platform (MSPP) 5-12
 - 5.3.4 Developing Architectures - Gigabit Ethernet (GigE) 5-14
 - 5.4 System Attributes 5-18
 - 5.5 Service Offerings 5-19
 - 5.6 Market Deployment Examples 5-20
- 6. Fiber To The Building (FTTB) and Fiber To The Home (FTTH) 6-1
 - 6.1 Overview 6-1
 - 6.2 Architectural Options 6-2
 - 6.2.1 APON Based on the FSAN Specification 6-2
 - 6.2.1.1 Architectural Overview 6-2

| | | |
|---------|--|------|
| 6.2.1.2 | System Characteristics | 6-3 |
| 6.2.1.3 | Advantages | 6-5 |
| 6.2.1.4 | Limitations and Implementation Issues | 6-5 |
| 6.2.2 | Gigabit Ethernet over Fiber (PON or Curb-Side Switched) | 6-6 |
| 6.2.2.1 | Architectural Overview | 6-7 |
| 6.2.2.2 | System Characteristics | 6-8 |
| 6.2.2.3 | Advantages | 6-9 |
| 6.2.2.4 | Limitation and Implementation Issues | 6-9 |
| 6.2.3 | Point-to-Point Fiber or Ring Topology (SONET/SDH) for FTTB | 6-10 |
| 6.2.3.1 | Architectural Overview | 6-10 |
| 6.2.3.2 | System Characteristics | 6-11 |
| 6.2.3.3 | Advantages | 6-12 |
| 6.2.3.4 | Limitations and Implementation Issues | 6-12 |
| 6.2.4 | Other Possible FTTH/FTTB Architectures | 6-13 |
| 6.2.4.1 | PON Based or Direct FTTB | 6-13 |
| 6.2.4.2 | Hybrid Solution for FTTH | 6-13 |
| 6.3 | Service Offerings | 6-14 |
| 6.4 | Market Deployment Examples | 6-15 |
| 7. | Operations and Network Management | 7-1 |
| 7.1 | TMN Overview | 7-2 |
| 7.2 | FITL Network Management | 7-5 |
| 7.2.1 | Fault Management | 7-5 |
| 7.2.2 | Configuration Management | 7-5 |
| 7.2.3 | Performance Management | 7-6 |
| 7.2.4 | Security Management | 7-7 |
| 7.2.5 | Accounting Management | 7-7 |
| 8. | Security | 8-1 |
| 8.1 | Physical Security Issues | 8-1 |
| 8.2 | Network Security Issues | 8-2 |
| 8.2.1 | Unauthorized Access | 8-2 |
| 8.2.2 | Virus Attacks | 8-2 |
| 8.2.3 | Signal Interception | 8-2 |
| 8.2.4 | Service Fraud | 8-3 |
| 8.3 | Security Measures | 8-3 |
| 8.3.1 | Authentication | 8-3 |
| 8.3.2 | Authorization | 8-4 |
| 8.3.3 | Data Encryption | 8-4 |
| 8.3.4 | Scrambling | 8-4 |
| 8.3.5 | Other Higher-Layer and/or Integrated Solutions | 8-5 |
| 8.4 | Cable Modem Security in an HFC Network | 8-5 |
| 9. | Evolution of FITL | 9-1 |
| 9.1 | Technology and Market Trends | 9-1 |
| 9.2 | The Road Ahead for FITL | 9-8 |
| 9.2.1 | Service Offerings | 9-8 |
| 9.2.2 | Architectural Options | 9-9 |
| 9.2.3 | Standard Maturity | 9-9 |

| | |
|--|------|
| 9.2.4 Product Development | 9-10 |
| 9.3 Value Statement for FITL | 9-11 |
| 9.4 Issues Associated with FITL Deployment | 9-12 |
| 9.4.1 Costs | 9-12 |
| 9.4.2 Powering | 9-12 |
| 9.4.3 ONT and Splitter Location | 9-13 |
| 9.4.4 Optical Network Construction and Operation | 9-13 |
| 9.4.5 Standards | 9-14 |
| 9.5 Current Outlook | 9-14 |
| Appendix A: Alternatives to FITL for Broadband Access | A-1 |
| A.1 The xDSL Family of Access Technologies | A-1 |
| A.2 HFC Networks and Cable Modems | A-4 |
| A.3 Wireless Access Technologies | A-7 |
| Appendix B: Major Players in the FITL Market | B-1 |
| B.1 Passive Optical Network (PON) Equipment Vendors | B-1 |
| B.2 Multiple Service Provisioning Platform (MSPP) Equipment Vendors | B-2 |
| B.3 Cable Modems and Cable Modem Termination System (CMTS) Equipment Vendors for Hybrid Fiber Coaxial (HFC) Network | B-3 |
| B.4 Gigabit Ethernet (GigE) and 10GigE Equipment Supplier | B-4 |
| Appendix C: Bibliography and References | C-1 |
| C.1 Telcordia Documents | C-1 |
| Note | C-1 |
| To Contact Telcordia Customer Service | C-2 |
| To Order Documents From Outside Telcordia | C-2 |
| To Order Documents Within Telcordia | C-2 |
| C.2 Other Documents | C-3 |
| C.3 Internet Sites | C-8 |
| Appendix D: Glossary | D-1 |

List of Figures

| | | |
|-------------|--|------|
| Figure 3-1 | Access Network Overview | 3-2 |
| Figure 4-1 | Generic FITL System | 4-2 |
| Figure 4-2 | Roles of the OLT | 4-3 |
| Figure 4-3 | Optical Distribution Network (ODN) Topology: Point-to-Point and Point-to-Multipoint Configurations | 4-5 |
| Figure 4-4 | Optical Distribution Network (ODN) Topology: Ring Configurations | 4-5 |
| Figure 4-5 | Roles of the ONU | 4-12 |
| Figure 4-6 | Roles of the Network Interface Unit (NIU) and the Network Interface Device (NID) | 4-14 |
| Figure 4-7 | Fiber In The Loop System Models (Typical PON Architecture) | 4-16 |
| Figure 4-8 | Generic FITL Services Architecture | 4-19 |
| Figure 4-9 | POTS-Capable FITL Network | 4-20 |
| Figure 4-10 | Video-Capable FITL Network | 4-22 |
| Figure 4-11 | Data-Capable FITL Network | 4-27 |
| Figure 4-12 | Voice over Packet-Capable FITL Network | 4-30 |
| Figure 4-13 | Integrated FITL System Reference Model | 4-34 |
| Figure 4-14 | Universal FITL System Reference Model | 4-36 |
| Figure 5-1 | Overview of Hybrid Fiber-Coaxial Network | 5-5 |
| Figure 5-2 | Passive Optical Network | 5-8 |
| Figure 5-3 | Applications of Resilient Packet Ring (RPR) Technology | 5-12 |
| Figure 5-4 | Existing and Potential MSPP Applications in FITL Systems | 5-14 |
| Figure 5-5 | 10 Gigabit Ethernet in the Metropolitan Area Network | 5-15 |
| Figure 5-6 | 10 GigE Over SONET Infrastructure in the Wide Area Network | 5-16 |
| Figure 5-7 | Ethernet FTTN/FTTC Systems | 5-17 |
| Figure 7-1 | Overview of the Telecommunication Network Management Architecture | 7-2 |
| Figure 7-2 | Summary of Functional Areas of FITL Network Components | 7-8 |
| Figure 9-1 | Projection for FITL Market Growth in Various Regions (1995 - 2004) | 9-7 |
| Figure A-1 | High-Level View of a Typical xDSL Architecture | A-2 |
| Figure A-2 | High-Level View of the xDSL Architecture with a Digital Loop Carrier (DLC) | A-3 |
| Figure A-3 | High-Level View of Hybrid Fiber-Coaxial Network | A-5 |

List of Tables

| | | |
|-----------|---|------|
| Table 4-1 | Reflectance Requirements for Bandwidths | 4-10 |
| Table 4-2 | Wavelength Allocation in Optical Transmission | 4-23 |
| Table 4-3 | Data Service Classifications | 4-26 |
| Table 5-1 | Spectrum Allocation for Cable Network | 5-6 |
| Table 5-2 | System Comparison of the Architectural Options | 5-18 |
| Table 7-1 | Network Management Functional Areas (MFAs) and Their Tasks . | 7-4 |
| Table 8-1 | Attacks and Remedies for Data, Voice, and Video Information . . | 8-6 |
| Table 9-1 | Access Fiber Timeline in Various Regions | 9-6 |
| Table 9-2 | Comparison of Market Growth for Different Access Alternatives . | 9-8 |