Microduct Cabling for In-building Networks
- Principle and Application
• Cabling Standards
• Components of Structured Cabling
  – Concept, Backbone cabling, COA, Equipment room, Distributors, Consolidation point, Administration...
• Fire Performance
• Design of Structured Cabling System
• Microduct Application
  – Microduct, ABC & ABF, Design topology...
• Conclusion
• Appendix
Cabling Standards
• Need for cabling standards
  – Cabling system is a critical element of any network
  – Significant number of network failure are caused by cable-related problems (more than 50%)

• Development of standards by related industry and organization;
  – accompanied developments in network and communication technology
Related Standards(1)

- **ANSI/TIA/EIA 568C**
  - “Commercial building telecommunications cabling standard”
  - American standard

- **ISO/IEC 11801 2nd edition**
  - “Information technology - Generic cabling for customer premises”
  - International standard based on ANSI/TIA/EIA 568

ANSI: American National Standards Institute
TIA: Telecommunications Industry Association
EIA: Electronic Industries Alliance
ISO: International Organization for Standardization
IEC: International Electrotechnical Commission
Related Standards (2)

- EN 50173 and EN 50174
  - Related European standards
- AS/NZS 3080
  - Related Australia and New Zealand standards
- Quite similar with different terminology
  - Hereafter this document is focusing on the ISO/IEC 11801
<table>
<thead>
<tr>
<th>ISO/IEC 11801</th>
<th>TIA/EIA 568</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distributor</td>
<td>Cross-connect</td>
</tr>
<tr>
<td>CD(Campus Distributor)</td>
<td>MC(Main Cross-connect)</td>
</tr>
<tr>
<td>BD(Building Distributor)</td>
<td>IC(Intermediate Cross-connect)</td>
</tr>
<tr>
<td>FD(Floor Distributor)</td>
<td>HC(Horizontal Cross-connect)</td>
</tr>
<tr>
<td>TO(Telecommunication Outlet)</td>
<td>TO</td>
</tr>
<tr>
<td>TP(Transition Point)</td>
<td>TP</td>
</tr>
<tr>
<td>CP(Consolidation Point)</td>
<td>CP</td>
</tr>
<tr>
<td>Campus Backbone</td>
<td>Interbuilding Backbone</td>
</tr>
<tr>
<td>Building Backbone</td>
<td>Intrabuilding Backbone</td>
</tr>
</tbody>
</table>
Generic Cabling System
Components of Structured Cabling
Structured Cabling System
A structured cabling system (SCS) is a set of cabling and connectivity products that integrates the voice, data, video, and various management systems of a building (such as safety alarms, security access, energy systems, etc.).

Source: The International Engineering Consortium
• Meaning of the “structured cabling”
  – System consists of a number of discrete subsystem or blocks
  – Each has specific performance characteristics
  – Blocks are organized hierarchically within a unified system

• If cabling does not confirm ISO 11801 model;
  – It is no longer “structured cabling”
• Benefits
  – Lower cost by vendor independent standard functions
  – Fast and flexible construction by standard approach
  – Simplified maintenance for add, move and troubleshoot
  – Work Predictable, performance guaranteed
• **Active** connection
  – Connection requires application-specific **equipment**

• **Passive** connection
  – Achieved by cross-connections using **patch cord** or **jumper**
Backbone Cabling
• Definition
  – Cabling between equipment rooms and building entrance facilities
  – In a campus environment, cabling between buildings’ entrance facilities
  – Vertical connections between floors
  – Includes all cables, cable terminations, campus backbone and building backbone

• Campus backbone + building backbone

Campus: premise containing one or more buildings
• **Definition**
  
  – Cable that connects *from campus distributor to building distributors*
  
  – Almost always *fiber optic* cabling, occasionally wireless for remote site

• **Includes**
  
  – Backbone cables
  
  – Any cabling components within building entrance facilities
  
  – Jumpers and patch cords in campus distributor
  
  – Connecting hardware for termination
• **Definition**
  – Extends from **building distributor(s) to floor distributor(s)**

• **Includes**
  – Backbone cables, Jumpers and patch cords in campus distributor
  – Connecting hardware for termination

• **For optical backbone, minimum count is 8 cores**
• Number of distributors
  – No more than 2 hierarchical levels of distributors are allowed

• Wiring topology
  – Hierarchical star topology

• Centralized optical architecture (COA),
  – is allowed as an alternative to optical distributor in telecommunications room for fiber deploy in work area
Star topology of equipment room and telecommunications rooms connected
Example of Building Backbone Cabling (2)

Backbone distribution in a **hierarchical star topology**

- **Building #1**
  - TR: Telecommunications room
  - Floor distributor
  - Work area

- **Building #2**
  - TR
  - Building distributor
  - Work area

**Campus distributor**

**Backbone cabling**
**Recommendation for Backbone Cabling**

- **Fiber optic cable**
  - Offers high **speed and long distance transmission, high bandwidth**
  - **Immune** to electromagnetic interference
  - Less likely to require replacement in near future

- **4-pair UTP within 90m**
  - Can be used for **short distance** cabling for voice and data
Horizontal Cabling
• **Definition**
  – All cabling extends from floor distributor (FD) to telecommunication outlet(s) (TO)

• **Includes**
  – Horizontal cables *within 90m*
  – Jumpers and patch cords in floor distributor
  – Termination of horizontal cables at TO and FD
  – Consolidation point (optional)
  – Telecommunication outlet outlet
• Minimum 2 cores of single or multi mode fibers

• 4-pair UTP
  – Low cost with wide applications
  – Minimum suggestion is Cat5E of maximum 1Gbps speed
  – Many new installations prefer Cat6 for future bandwidth
A typical small office with **horizontal cabling** running to a single telecommunications room of a floor.
Horizontal cabling in a star topology from the telecommunications room
Cabling Rules
• Apply to all cable installation
  – Cable tie must not be too tight
  – Cable must not be forced around bends tighter than specification
  – Minimum bend radius must be kept
  – Cable bundles must not be too big
  – Cables must not be dragged around or across sharp edges
  – Power cables must cross data cables at right angle

• Clipping intervals on wall surfaces
  – 300mm for unsupported horizontal, 1,000mm for supported, 400mm for vertical runs
Cabling Pathway
• **Requirement**
  - Keep *minimum bend radius*
  - Not less than 90° *bends* along pathways
  - Less than 50% *fill-up* in pathway’s cross-sectional area
  - *Separation* from power lines and grounding

• **Possible choices**
  - Ladder, cable tray, conduit, J-hook etc.
Cross-connection vs. Interconnection
2 types of schemes used to connect cabling subsystems to each other and to equipment

Cross-connect gives greater flexibility in cabling scheme
Centralized Optical Architecture (COA)
• Definition
  – Combined backbone/horizontal channel
  – For ISO 11801 model, more than three layers cannot exist

Generic cabling (left) and **centralized cabling** (right) scheme
• Benefits
  – Using optical fiber, no need to go through various layers, directly connected from equipment room to user’s workstation
  – Substantial savings by eliminating cross-connects, associated cabinets, active equipments, power suppliers, floor spaces etc.

• Also referred as;
  – Fiber-to-the-desk (FTTD)
  – Optical home-run
  – Collapsed backbone
• Provides
  – **Flexibility of designing** optical fiber cabling
  – **More simple construction** by splice or interconnection within total optical cable length of 2km (ISO 11801)
Work area
• Definition
  – Building space *where user interacts* with telecommunication terminal equipment

• Includes
  – All *cable components* between communication outlet(s)
  – End-user telecommunication equipments like telephone, workstation, printer and TO itself
Equipment Room
• Definition
  – An area within a building where equipment is housed
  – More complex equipments than those inside
    “telecommunications room”
  – Provides termination point for building backbone cabling

• Includes
  – Building telecommunication equipments like PBX, server and switch
  – Termination for wiring
  – Possibly contain “telecommunications room”
Example of an Equipment Room

Equipment room, backbone cabling and telecommunications rooms
Telecommunications Room
• Definition
  – Enclosed space for housing telecommunication equipments, cable terminations and distribution frames (distributors)
  – Where horizontal cabling to TOs originates, backbone cabling terminates
  – The standard recommends at least one per floor

• Includes
  – All the hardware for connection of horizontal wiring to vertical wiring
  – Possibly networking equipments like LAN hubs, switches, routers and repeaters
• Care to **avoid**
  – Cable stress, tight bend, staples, excessive tension and wrapping

• **Use**
  – Only **appropriate connecting hardware** per specifications

• **Termination of horizontal cabling**
  – **Should go** directly not to application-specific device but **to TOs**, and use **patch cords** for device connection
Building Entrance Facility
• Definition
  – Facility for the acceptance of telecommunication cables into a building
  – Transition occurs from external to internal cabling
  – Entrance facility may share space with equipment room, if necessary

• Includes
  – Campus-wide backbone connections
  – Network “Demarcation point” between public and private network
Example of a Building Entrance Facility

Entrance facility for campus and telecommunication wiring
Distributors
• **Definition**
  - **Patch panel** is known as “distributor”
  - Distributor permits **termination of cable** elements,
  - and their **connection** by jumpers, termination blocks and/or cables to another cabling element (another cable or patch panel)
  - Any distributor may have an **equipment interface**
• Campus distributor (CD)
  – Distributor from which campus backbone cabling starts

• Building distributor (BD)
  – Distributor in which building backbone cable(s) terminate(s) and at which connections to campus backbone cable(s) may be made

• Floor distributor (FD)
  – Distributor used to connect between horizontal cable and other cabling subsystem or equipment
• Number and type depends on;
  – Geography and size of campus or building
  – Strategy of user

• Usual approach;
  – Only one campus distributor (CD) per campus
  – One building distributor (BD) per building
  – One floor distributor (FD) per floor
Consideration for Distributors (2)

- **For small single building,**
  - If it is **small enough** to be served by a single building distributor (BD),
  - then, **no need for campus backbone cabling**

- **For large buildings,**
  - **Multiple building distributors (BD) will serve,**
  - They are **interconnected via a campus distributor (CD)**

  ![Generic cabling with combined BD and FD](image)
• For floor distributor (FD)
  – Minimum one floor distributor (FD) should be provided for every floor
  – Floor area exceeding 1,000m², additional FD should be provided per each 1,000m²

• Location of FD
  – Should ensure lengths of patch cord/jumpers and equipment cord are minimized

• Maximum channel lengths
  – Horizontal < 100m
  – Horizontal + building & campus backbone < 2,000m
Consolidation point
• Definition
  – **Connection point in horizontal cabling subsystem** between a floor distributor and a telecommunication outlet (TO)
  – Required for **flexibility of relocating TOs** in work area
  – **One** CP is permitted between a FD and any TO
  – Does **not provide** an equipment interface
  – Similar function of MUTOA

• Includes
  – Only contain **passive connecting hardware**, like IDC, 8-pin plug and socket, patch panel etc.

IDC: Insulation Displacement Connection
• **Requirements**
  – Each work area group is served by at least **one CP**
  – CP can serve **maximum 12** work areas
  – CP should be located in accessible location
  – For UTP wiring, CP should be located within 15m from FD
• TP expression is no longer exist, use CP
  – For mechanical **joint of dissimilar cables** at the location of consolidation point,
  – like round and flat cable interface
Telecommunications outlet
• Telecommunication outlet (TO)
  – Fixed connecting device where horizontal cable terminates

• Requirements
  – Each individual work area shall be served by a minimum two TOs
  – First outlet should be for 4-pair UTP,
  – Second outlet may be for fiber optic or 4-pair UTP

• Single user TO
  – One assembly of TOs serves a single work area
  – Length of work area cords should be minimized
  – It should be located in user-accessible location
• Multi-user TO assembly (MUTOA)
  – MUTOA is single assembly of TOs that serves more than one work area
  – A MUTOA can serve maximum 12 work areas (similar function of Consolidation point)
  – A MUTOA should be located in accessible location
  – Length of work area cords should be minimized
• **Minimum 2 fiber connectors couplings,**
  – must be provided for termination at TOs

• **To prevent damage,**
  – TOs must provide a means of *securing and minimum bend radius* of 30mm

• **At least,**
  – TOs must provide 1m length *fiber storage* inside

• **Surface-mount box of TOs,**
  – must be *attachable* on top of standard 4”x4” electrical box
Example of a TO Construction

A telecommunication outlet (TO) with a UTP for voice and a UTP/STP/Fiber for data
Administration
• **Definition**
  – Process that includes *all aspects of premises cabling activities*
  – To maintain *accurate information* for the assets

• **Components** adapted from IEC 14763
  – Identifier
  – Label
  – Pathway
  – Record
  – Space
  – Work order

Cabling administration scheme
• It covers;
  – Documenting, managing, testing of system, compiling and maintaining system architectural plans

• Must recorded items for administration
  – Pathway
  – Ground
  – Cable
  – Termination
  – Ground
Cabling Models Summary
Cabling Models Summary

Generic cabling model
Redundancy
• For security or reliability
  – Provide protection against failure
  – Like fire damage or failure of public network feeder cable

Installation with redundancy
Fiber
• Multimodes depending on core diameter
  – 62.5/125-micron (OM1) and 50/125-micron

• Within 50/125-micron
  – Standard 50-micron fiber (OM2)
  – Higher bandwidth option known as 850nm laser-optimized 50/125-micron (OM3)
  – OM3 has much higher bandwidth and supports Gigabit Ethernet applications to longest distances

• Single mode
  – G.652.D (OS1)
  – Most widely used for general communication
## ISO 11801 2nd edition optical fibre classes

<table>
<thead>
<tr>
<th>Fibre type</th>
<th>Core diameter (μm)</th>
<th>Minimum modal bandwidth (MHz km)</th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Overfilled launch bandwidth</td>
<td>Effective modal bandwidth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>850 nm</td>
<td>1300 nm</td>
</tr>
<tr>
<td>OM1</td>
<td>50 or 62.5</td>
<td>200</td>
<td>500</td>
</tr>
<tr>
<td>OM2</td>
<td>50 or 62.5</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>OM3</td>
<td>50</td>
<td>1500</td>
<td>500</td>
</tr>
<tr>
<td>OS1</td>
<td>single mode</td>
<td>N/s</td>
<td>N/s</td>
</tr>
</tbody>
</table>

N/s, not specified.
- **Limit for fiber link**
  - Based on total *connecting hardware attenuation of 1.5dB*
  - Additional connection will be allowed within the limit

<table>
<thead>
<tr>
<th>Max. Transmission speed (Mb/s)</th>
<th>300 m</th>
<th>500 m</th>
<th>2000 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>OM1</td>
<td>OM1</td>
<td>OM1</td>
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<tr>
<td>100</td>
<td>OM1</td>
<td>OM1</td>
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</tr>
<tr>
<td>1000</td>
<td>OM1</td>
<td>OM2</td>
<td>OS1</td>
</tr>
<tr>
<td>10000</td>
<td>OM3</td>
<td>OS1</td>
<td>OS1</td>
</tr>
</tbody>
</table>
Connecting Hardware
Connecting Hardware(1)

• Applicability
  – Minimum performance requirements at -10~60℃ condition
  – Appropriate enclosure or indoor installation required

• Location
  – in CD, BD and FD
  – in Consolidation point and TO
  – in Building entrance facility
• Mounting
  – To provide flexibility by adaptor plate or enclosure

• Installation practice
  – Avoid cable stress due to tension, sharp bends and tightly bunched cables
  – Permit minimal signal impairment by proper preparation and termination with well organized cable management,
  – and adequate clearance for access and cable dressing
Connectors

- **SC**
  - Most widely used

- **LC and MT-RJ**
  - Twice packing density with small form factor (SFF)
Marking and color coding

- To get correct and consistent connection
- Alphanumeric or color identifier may be used

<table>
<thead>
<tr>
<th>Type</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multimode 50 μm and 62.5 μm</td>
<td>Beige or black</td>
</tr>
<tr>
<td>Single mode PC</td>
<td>Blue</td>
</tr>
<tr>
<td>Single mode APC</td>
<td>Green</td>
</tr>
</tbody>
</table>
• Fiber termination
  – Organizing and protection purpose
  – Nearly optical cable always ends in patch panel
  – Rack or wall mounted

• Requirements
  – Cable support and glanding
  – Splice protection and Fiber organizer
  – Slider for each access
  – Eye safety from light source

• Passive elements in structure cabling;
  – Budget pressure is low, but critically important for reliability
Fire Performance
• Plenum
  – Any area within a building that carries environmental air like return airflow from air-conditioned area
  – Fire in this area will be extremely dangerous and spread fast
  – Highest regulation applied

• Riser
  – Vertical axis like elevator path
  – Next highest regulation applied
• **Plenum rate cable**  
  – NFPA 262 (formerly UL 910)

• **Riser**  
  – UL 1666

• **General purpose**  
  – UL 1581

• **Regulation**  
  – USA is the **most strict** country for fire safety  
  – EU and other countries depend on each regulation
Design of Structured Cabling System
• Design checklist
  – Standard philosophy
  – Overall cabling topology
  – Optical fibers
  – Determination of copper cable categories/bandwidth
  – Density of outlets
  – Selection of copper cables
  – Fire rating
  – Location and specification for Equipment rooms
  – Location and specification for Telecommunications room
• **Design checklist** continued
  – Cable *containment* system
  – Requirements for *earthing* and *bonding*
  – *Administration* system
  – Civil works issues for *outdoor cable installation*
  – Identification for *specific installation*
  – Decision for *test* and *handover regime*
  – *Prequalification* and *bidding*

• **In-depth consideration and experience needed**
  – For more details, confer *documents listed in References*
Microduct Application
Benefit of Microduct Cabling

- Ducts installed separately in advance;
  - Fiber installed incrementally per user demand growth
  - Fiber not damaged unlike conventional pulling
  - Splice points minimization; cost and time saving
  - Easy network upgrade; more fibers and/or different type, replacement to new type
  - Ability to add fiber without any disruption to office environment
  - Simplified design

- Cost efficient and future-proof solution
Microduct
• Applicable products
  – Low smoke zero halogen (LSZH)
  – Hybrid LSZH
  – Duct install (DI)
  – Primary tube

LSZH, Hybrid LSZH, DI and primary tube
• For Building backbone and Horizontal cabling

• Low smoke zero halogen (LSZH)
  – IEC 60332 part 1 & 3, IEC 60754
  – Minimized toxic gas emission and self-extinguish
  – Safe but expensive

• Hybrid LSZH
  – LSZH sheath + PE primary tubes inside
  – Compromising performance with better handling at lower cost
• For Campus backbone, Building backbone and Horizontal cabling

• Backbone cabling with high count fibers
  – Blowing ABC into DI with 12/10 tube is better

• Horizontal cabling
  – Blowing ABF up to 12 cores is common
• For Horizontal cabling
  – FD to TOs wiring connection
  – Sheathed 1 tube gives better protection

• Separate bundles
  – Not desirable for backbone cabling
ABF & ABC
• **Air blown fiber (ABF)**
  - 2~12 fibers in a bundle
  - Single and/or multi-mode

• **Air blown Cable (ABC)**
  - Up to 288 fibers
  - For campus/building backbone cabling
Design Topology
• A small and medium size building
  – **COA(FTTD or Collapsed backbone)** cabling recommended
  – **Direct connection** of tube/ABF from BD to TO
  – At BD, cable termination, fiber splice, patching, splitter accommodation occur,
  – shelf and rack for duct/ABC/ABF termination necessary
• Completely collapsed scheme
  – One CD can cover adjacent buildings together
  – For buildings within 1km radius

• Tube supply for each floor
  – Tube branch box or mid-span of microduct in TPS
  – Backbone cabling with primary tube should be avoided

• Fiber termination at TO
  – Pigtail splice or field installable connector
  – G.657

TPS: Telecommunication Pipe Shaft
Tube branch box
Mid-span
• Many TOs in a floor
  – **FD needed** for connection to TOs (more than 100)
  – At **FD**, cable termination, fiber splice, patching, splitter accommodation occur,
  – shelf and rack for duct/ABC/ABF termination necessary
• Tube supply for each floor
  – At FD, Rack and shelf for ABC termination and passive components
  – ABF blowing to each TO
  – ABC from FD to BD recommended

• Fiber termination at TO
  – Pigtail splice or field installable connector
  – G.657
• **Backbone cabling**
  - Microduct cabling to FD
  - Apply either ABC or ABF

• **In FD,**
  - Equipments like switch and UTP termination,
  - rack and shelf or frame for fiber termination exist

• **CP**
  - may exist for UTP wiring flexibility (optional)

**Dotted line: UTP wiring**
Installation
• Must do
  – Install by well-trained workers
  – Keep minimum bend radius
  – Use end-cap against dust and moisture
  – Cut using appropriate tools
  – Fit connector properly
  – Use dedicated blowing equipments

• Must not do
  – Deformation; squeeze, kink, step etc (blowing problem)
  – Surface scratch (blast by air-pressure)
  – Tie too tight (deformation)
  – Exert excessive pulling force (diameter shrink and deform.)
• High stories building
  – Sometimes, fiber pull-out by gravity occur
  – Can cause bending loss and fiber breakage

• To avoid,
  – Use gas-block connector to hold fibers, or
  – Make loops to keep ABF with excess length
• Excessive bends
  – Building inside has many corners along duct and tray route
  – Sometimes, partial sheath peel off will be helpful to improve bending radius

• Secure enough tube excess length
  – Useful for blowing activity and future maintenance
Conclusion
• **Structured cabling**
  – Provides better *network performance* with standard blocks
  – Enables *hierarchical design* and construction
  – Makes vendor-independent *high-quality cabling at low cost*

• **Microduct for In-building application**
  – *Future-proof* solution for in-building networks
  – *Flexible construction* with ABC/ABF combination
  – COA is *cost-effective* and *highly reliable* topology
Appendix
References (1)

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THANK YOU