This document provides a high-level description of the communications network technologies used by New York City Transit.

Due to the security sensitive nature of information, the content in this document is meant to be general. Where possible, industry standards are referenced to allow participants to further research the specifics associated with the technologies and standards.

NYCT's Wired Communications Network

The information in this section is categorized based on the OSI (Open Systems Interconnect) model. Information starts from the cable infrastructure, then Layer 1 and above.

Cable Infrastructure

Communications network uses many different cable types with different physical properties. The specific cable type depends on the installation and operating environment.

Two major types of cables used are:

- Conventional Singlemode Fiber (ITU-T G.652.D and G.657)
- CAT6 (TIA/EIA-568)

Cables with specific properties that meet the subway environment are used in all installations. Specifications include NFPA 70 (National Electrical Codes) and NFPA 130 (Standard for Fixed Guideway Transit and Passenger Rail Systems).

Some specific cable types and properties that are critical to meet the harsh subway operating environment include:

- Low-smoke zero halogen jacket (to meet smoke and toxicity requirements)
- Thermoset cross-link polymer jacket (to meet safety requirements)
- Metallic shield or aramid kevlar protection under jacket (to meet installation environment and for rodent-resistance)
- Water-blocking tape under jacket (to meet installation environment and submersion in flooded manholes)

Different installation types will require one or more (or all) of the above properties for a single cable. NYCT has specific internal requirement for the Fiber Optic cable used in the subway environment.

Layer 1 (Physical Layer)

The following Layer 1 technologies are used in NYCT Communications Network.

Plesiochronous Digital Hierarchy (PDH)

Plesiochronous Digital Hierarchy (PDH) is an old legacy technology, based on Time Division Multiplexing (TDM). This was the technology used prior to the standardization of the Synchronous Optical Network (SONET). It is based on DS0, DS1, DS3 signal hierarchy.

Protection mechanism uses linear circuit protection protecting at DS1 level. This network is mainly used to carry voice and low-rate modem data over telephony circuit DS0 (such as 9.6k or 56k modem circuit). NYCT calls this network the “Async” network.

This network cannot be used for any new / future applications and is in the process of being de-commissioned.

Dense Wave Division Multiplexing (DWDM)

Dense Wave Division Multiplexing (DWDM) technology is used to create “virtual fiber” in locations where NYCT has a lack of available fiber cable. DWDM is installed in very limited locations. It provides point to point configuration used to alleviate fiber exhaust.

Wavelength grids are based on ITU-T standard G.694.1 (Spectral grids for WDM applications: DWDM frequency grid).

Each wavelength carries up to 2.5 gigabit signal. It is mainly used to carry SONET traffic (see below).

Reconfigurable Optical Add-Drop Multiplexer (ROADM)

Reconfigurable Optical Add-Drop Multiplexer (ROADM) technology is the next evolution of the DWDM technology. It provides additional flexibility in terms of adding, dropping and link engineering wavelengths. ROADM also supports point to point and protected wavelength configuration. ROADM is installed in very limited locations.

ROADM technology is based on ITU-T standards for Optical Transport Network (OTN), the major standard include ITU-T G.709 (Interfaces for the optical transport network).

Each wavelength carries up to 10 gigabit signal. It is mainly used to carry Connection oriented Ethernet traffic (see below).

Synchronous Optical Network (SONET)

Synchronous Optical Network (SONET) technology is based on ITU-T G.707, customized for the North American marketplace by ANSI T1.105 and Telcordia GR-253-CORE. SONET ring protection mechanism, based on Bidirectional Line Switched Ring (BLSR - GR-1230-CORE) and Unidirectional Path Switched Ring (UPSR - GR-1400-CORE), are used to support failure recovery.

SONET rings operate in OC-48 line rate. It is mainly used to carry TDM traffic and ATM traffic (see below).

Layer 2 (Data Link Layer)

Asynchronous Transfer Mode (ATM)

Asynchronous Transfer Mode (ATM) technology is based on ITU-T I.361 (B-ISDN ATM layer specification) and ATM Forum's Private Network-to-Network Interface (PNNI). ATM PNNI is used to set up Soft Permanent Virtual Circuit to provide a protected circuit in the ATM layer. Permanent Virtual Circuit is used to support unprotected circuits.

ATM network operates in OC-3 and OC-12 line rate. It is used to carry both TDM and IP traffic.

Ethernet

Ethernet network is a dynamic non-deterministic network technology that was originally developed to support Local Area Network (LAN). It is defined by IEEE 802 set of standards (IEEE 802.1D and IEEE 802.3). Data traffic is separated by use of Virtual LAN (VLAN). Priority mechanism is used to prioritize traffic over the network.

Failure recovery uses Spanning Tree Protocol (STP), Rapid STP (RSTP). Multicast support uses Internet Group Management Protocol (IGMP). Multicast capability is used for certain applications that require distribution of information to multiple stations.

Ethernet also supports Power Over Ethernet (POE - IEEE 802.3af) and POE+ (IEEE 802.3at). POE/POE+ is used to power end devices installed across the subway stations.

Link Aggregation Control Protocol (IEEE 802.1AX) is used to support better handling of failures, and to support traffic rates higher than what can be supported by a single interface.

Ethernet LAN operates in Gigabit line rate. It is mainly used to carry data traffic.

Connection Oriented Ethernet (COE)

Connection Oriented Ethernet (COE) is based on the Ethernet standard, but extended to support more deterministic network behavior with better failure recovery and fault management capability. COE extends Ethernet by adding the following major capabilities:

- Ethernet Operations, Administration and Maintenance (OAM) (IEEE 802.1ag and ITU-T Y.1731)
- Precision Time Protocol (IEEE 1588v2)
- Ethernet Linear Protection Switching (ITU-T G.8031)

COE operates in 10 Gigabit and multi-10 Gigabit (over ROADM - see above) line rate. It is mainly used to carry data traffic, with pseudowire used to support TDM emulation over Ethernet (based on Internet Engineering Task Force [IETF] standards).

Layer 3 (Network Layer)

Internet Protocol (IP)

Internet Protocol (IP) is based on IETF standards. NYCT uses various dynamic routing and recovery protocols defined by IETF. These include all the industry-standard protocols, such as the following:

- Virtual Router Redundancy Protocol (VRRP)
- Open Shortest Path First (OSPF)
- Routing Information Protocol (RIP)
- Protocol Independent Multicast Sparse Mode (PIM-SM)
- Border Gateway Protocol (BGP)

Network Management System (NMS) and Element Management System (EMS)

NYCT deploys centralized management systems to monitor the communications network. Hierarchical management using

- NMS for network-wide technology independent view of the communications system
- EMS to monitor each vendor-specific technology system

The NMS and EMS systems provide the functions as defined by the ISO Telecommunications Management Network model for network management. The functional areas are: fault, configuration, accounting, performance and security (FCAPS)

Network Equipment

Because of the harsh environment in the subway system, equipment is installed in enclosures. In certain cases, enclosures must be sealed and cannot have air conditioning. This drives NYCT to use ruggedized/environmentally hardened equipment that can operate in a high-temperature environment. Equipment needs to operate in the following environmental conditions

- High temperature (inside sealed non-air-conditioned enclosures)
- High humidity (inside sealed non-air-conditioned enclosures and in certain damp environments)
- High EMI (near motors and transformers such as in traction power substations, pumps, fans)
- High vibration (in elevated stations and near track areas)
- Steel dust (especially critical when installed in enclosure close to track areas)

NYCT's Wireless Communications Network

New York City Transit's Wireless Communications Network has systems that support operations as well the general Subway riding population.

Operational Radio Systems

NYCT operates and maintains voice radio systems for operational groups via base stations and leaker feeder coaxial antenna cables.

Commercial Wireless Communications System

Commercial cellular services and Wi-Fi is present in all underground NYCT subway stations through NYCT's partnership with Transit Wireless.

Transit Wireless has an exclusive contract with the Metropolitan Transportation Authority (MTA) and NYCT to finance, design and build a neutral host distributed antenna system (DAS) network and a Wi-Fi network in the underground stations of the New York City subway system. This is a unique public-private partnership that is being financed entirely by Transit Wireless, not requiring any funding from the transit authority subway riders or taxpayers.

In 2011, Transit Wireless connected the first six stations in the Chelsea neighborhood of Manhattan. From there, the project expanded throughout Manhattan, Queens, the Bronx, and Brooklyn. The project was completed in December 2016, two years ahead of the original time frame. All stations in the New York City underground subway now have Wi-Fi connectivity as well as cellular connectivity on AT&T, Sprint, T-Mobile and Verizon networks.