ECE478 Homework 7

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REPORT

The synchronous optical network, known as SONET, is the American National Standards Institute (ANSI) standard for multiplexed optical telecommunications, which began development in 1984 [1]. For North America, SONET is used, and for Europe, SDH is used; SDH stands for synchronous digital hierarchy. Overall, SONET allows for efficient telecommunications with less needed hardware and ease of use due to synchronization. The need for the standard arose in the mid-1980s to allow for the mix and match of different equipment when constructing a telecommunications network.

The use of SONET, or more generally an optical communications scheme, is to tap into the benefits of optical fiber transmissions over other traditional communications mediums. Optical fibers themselves are robust to interference, have lower bit error rates, have better bandwidth than copper wire, and require less signal boosting in between network nodes [2].

SONET, as previously mentioned, uses synchronized digital signals, which means that it uses digital signals of the same bit rate [1]; most importantly, each signal is fundamentally driven by the same (primary) clock. This is an improvement of other schemes, which use either plesiochronous or asynchronous signals where data rates between signals are not in line with a singular reference clock.

SONET is constructed from synchronous transport signal (STS) levels. This ranges from STS-1 to STS-192. These levels have bit rates which are integer multiples N of the STS-1 bit rate given a level STS-N. STS-1 has a bit rate of 51.84-Mbps, and STS-192 is 192 times that at 9.953-Gbps [1].

The STS-1 level is constructed of the “transport overhead” and the “synchronous payload envelope”, which itself is constructed of more overhead and the payload [1]. The payload being the pertinent data being transmitted. Each STS-1 frame consists of 6,480 bits over a 125-μs window, which makes up it’s 51.84-Mbps bit rate. The frame itself is 9 rows and 90 columns, where each column is 8-bits, and the first 3 are used for overhead, and the last 87 are used for data payload. For example, the STS-1 level can multiplex 21 2.048 Mbps signals, or 28 T1 signals [1].

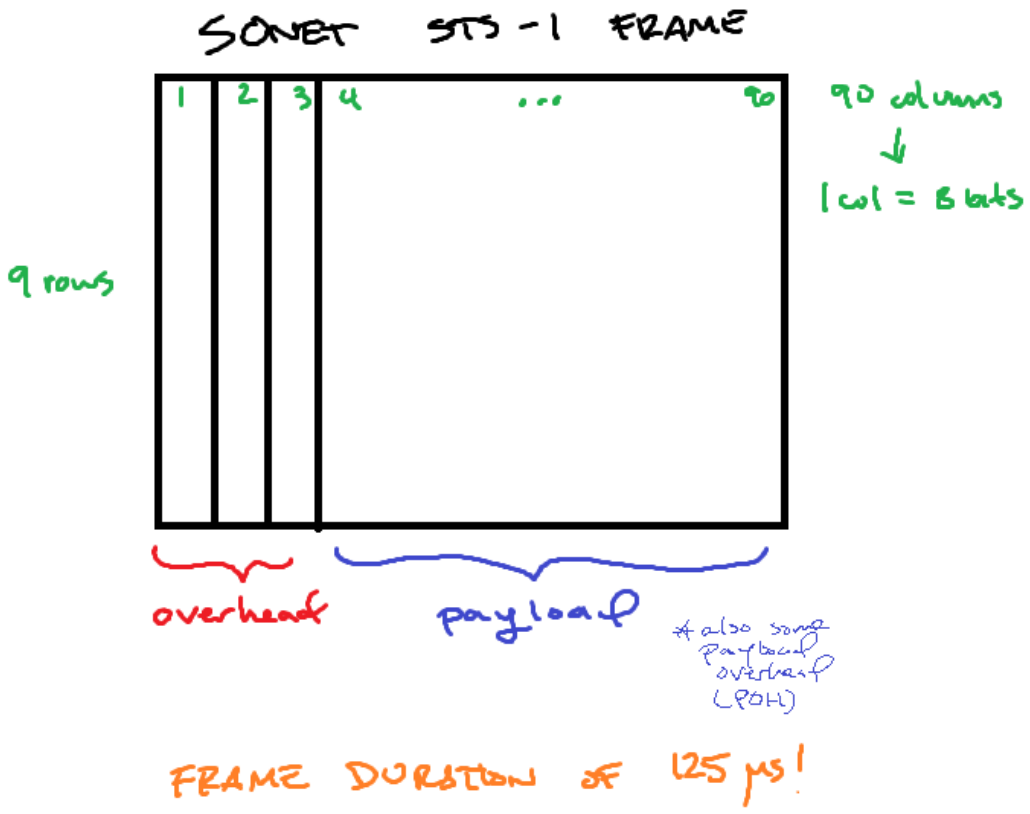
The overhead sections of the SONET level frames are used to convey a lot of information regarding framing, signal health, parity, and other things required by network elements [1].

SONET can be used to consolidate telephone signals (T1 or DS-1) in point-to-point applications. Or, using add-drop multiplexers (ADMs), signals can be dropped or added to the optical light beam in the middle of the network. By interconnecting ADMs series with send and receive fibers, a ring network can be created which allows for flexible data transfer, in two directions, which is at the same time robust to fiber failure [1].

From personal experience, industrial SCADA networks rely heavily on RJ45 CAT5 ethernet transmissions to allow for plant-wide data transmission. However, the industry is rapidly adopting fiber communications, where SONET can provide robust communications. This would be especially useful for PLC to sensor communications where large metallic machinery can easily cause interference for analog and digital signals.

Another application for this can be used in the growing Smart Grid, which is going to rely on IoT communications [3]. However, the complete transition from ethernet to optical with SONET is far away, due to the simplicity of ethernet [3].

APPLICATION



The STS-1 level has 90 columns of 8 bits each over 9 rows, all inside a 125-microsecond duration.

$$R_b^{STS-1} = 9(90)(8\text{ bits})/125\mu s = 51.84\ Mbps$$

As mentioned previously, the higher levels have bit rates of integer multiples of R_b^{STS-1}. STS-3 contains 3 STS-1 levels, STS-12 contains 12 STS-1 levels, STS-24 contains 24 STS-1 levels, and so on to STS-192 which has 192 STS-1 levels.

LEVEL	MULTIPLE	BIT RATE (Mbps)
STS-1	1*STS-1	51.84
STS-3	3*STS-1	155.52
STS-12	12*STS-1	622.08
STS-24	24*STS-1	1244.16
STS-48	48*STS-1	2488.32
STS-192	192*STS-1	9953.28

REFERENCES

[1] Tektronix, "Synchronous Optical Network (SONET)," The International Engineering Consortium.

[2] S. Kartalopoulos, Understanding SONET/SDH and ATM: Communications Networks for the Next Mellennium, Wiley-IEEE Press, 1999.

[3] S. Tang, "Advantages of Ethernet vs. SONET/SDH," TC Communications.