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Development of a University Networking Project

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INTRODUCTION

A communications channel has an important dependence for the channel capacity (C, in bps) to channel bandwidth (W, in Hz) ratio; this is capacity per unit bandwidth on signal to noise ratio (S/N, power of the signal over power of noise). Shannon's formula gives an upper limit for this dependence (Shannon & Weaver, 1949), $C/W=\log_2(1+S/N)$, which represents channel efficiency. Phase lock loops for waves and data symbols in the presence of noise have been given (Reis, Rocha, Gameira, & Carvalho, 2005).

Properties of electromagnetic fields can be described by a set of four equations, known as the Maxwell's equations, due to J.C. Maxwell. From these basic equations, Maxwell discovered in 1865 the proof for electromagnetic waves, propagating in vacuum at light speed (Maxwell, 1954). It was concluded that light should be an electromagnetic wave. Heinrich Hertz in 1888 produced electromagnetic waves from electric and magnetic fields.

Since long ago, electromagnetic waves in wide frequency ranges have been extensively used in telecommunications. In particular, electromagnetic waves have been increasingly used for data communications in computer networks. It is the case in wide area networks (WANs), metropolitan area networks (MANs), local area networks (LANs), and personal area networks (PANs). When the waves travel through an unguided medium such as the atmosphere, there are wireless communications. For a guided medium, such as an optical fiber, there are fixed (wired) communications. It is also the case of copper cabling systems, involving electric signals. Accordingly, there are wireless networks and fixed (wired) networks. Wireless communications related to LANs originate as wireless local area networks (WLANs). Similarly, if they relate to PANs, wireless personal area networks (WPANs) arise.

LANs and Ethernet

LANs were developed in the late 1970s and early 1980s to constitute communication networks that provide interconnection of data communication devices within a small geographic area, say 10 km (Stallings, 1987). A family of IEEE 802 standards (IEEE-802 standards) exist for LANs. Ethernet, Token Ring, and Fiber-Distributed Data Interface (FDDI) are examples of LAN technologies. Ethernet, corresponding to IEEE 802.3, has the most widely installed base worldwide. The Ethernet technology was developed in the mid-1970s by Xerox, Intel, and DEC, following its invention by Bob Metcalfe and David Boggs from Xerox in 1973. This was known as the experimental Ethernet at 2.94 Mbps that was patented in 1977 (U. S. Patent No. 4,036,220, 1977). Ethernet II at 10 Mbps appeared in 1982. Several other versions of Ethernet were developed, initially based on the Carrier Sense Multiple Access with Collision Detection (CSMA/CD) method for medium access control, which has been altered. Several types of Ethernet have existed, supporting different physical media and speed. They are represented as x-Base-y, where x represents binary rate in Mbps and y corresponds to the type of medium used. Base stands for baseband, where the whole bandwidth is used to transmit digital signal without modulation

(Stallings, 1987).

The main types of 10 Mbps Ethernet designations, standards, and dates are: 10-Base-5, 802.3 (1983); 10-Base-2, 802.3a (1985); 10-Base-T, 802.3i (1990); and 10-Base-F, 802.3j (1993). Fast Ethernet corresponds to 100 Mbps Ethernet, 802.3u (1995). It presents autonegotiation and full-duplex capabilities, enabling switching solutions that eliminate collisions and collision detection; propagation delay no longer presents a problem. 100-Base-TX and 100-Base-FX over copper and optical fiber, respectively, are the main types of fast Ethernet. Gigabit Ethernet at 1 Gbps follows the 802.3z (1998) (for 1000-Base-SX and 1000-Base-LX over optical fiber) and 802.3ab (1999) (for 1000-Base-T over copper) specifications of IEEE and Gigabit Ethernet Alliance. An introduction to Gigabit Ethernet has been given (Cisco Systems, 2000). Full-duplex is permitted, except for 1000-Base-T that is half-duplex. 10 Gigabit Ethernet follows the 802.3ae (2002) (for optical fiber, full-duplex, only) specifications of IEEE and 10 Gigabit Ethernet Alliance. An overview of 10 Gigabit Ethernet switching technology and applications has been given (Cisco Systems, 2005). On June 8, 2006, 802.3an was approved for 10G-Base-T over copper (IEEE-802 standards). Thus, Ethernet has evolved from LAN to MAN applications, as the distances involved are within the reach of optical fiber. Metro Ethernet is an example of this, permitting coverage of a metropolitan area and subscribers to connect to a WAN such as the Internet. Accompanying the technology evolution, new networking equipment has been designed by the main constructors, especially in the areas of switching and routing (Enterasys Networks, 2004a, 2004b, 2004c, 2006).

Wireless Communications

Microwaves have been highly important in telecommunications. Their frequency (f) range from 2 to 40 GHz corresponds, in atmosphere, to a wavelength (λ) range from 15 cm to 0.75 cm. Halsey and Johnston (1989) have given a historical perspective of microwaves since 1923, when they were demonstrated by the U.S. Naval Research Laboratory. Several applications were presented such as radar, communications, communications satellite, heating, and scientific applications. Extensive studies have been presented for radio-wave propagation, including line of sight microwave (Freeman, 1998; Kirby, 1975; Salema, 2002). Other studies are available for the free space propagation model and the basic propagation mechanisms such as reflection, diffraction, and scattering (Rappaport, 2002). While reflection matters for objects whose dimensions are large compared to λ, scattering is important for media consisting of objects whose dimensions are small compared to λ. Diffraction in surfaces with sharp edges is very important and, therefore, the geometry and sizes of the Fresnel zones have great interest. As microwaves follow straight line trajectories, building a wide area microwave infrastructure requires repeater stations typically located at strategic points such as hilltops, mountaintops, or towers at ~50 km intervals. Free-space loss under idealized conditions is such that $P_r/P_t = (A_r A_t f^2) / [(c\ d)2]$ represents the ratio of received power P_r over transmitted power P_t for areas A_r and A_t of the receiving and transmitting antennas, respectively; f is the carrier frequency, $\lambda = c/f$ is the wavelength, and c is the light velocity in air. For the 2-18 GHz band, 7-220 MHz bandwidth and 12-274 Mbps data rates are quoted (Stallings, 1998). It is important to have clear unobstructed line-of-sight paths between emitter and receiver. By locating the antennas at higher heights above ground floor, longer ranges can be obtained, provided there are directional antennas and narrow beams for point-to-point connections. Improved results can be achieved by using suitable antennas (Pacheco de Carvalho, Reis, Gomes, & Veiga, 2006). By having an omnidirectional antenna at a suitably located point, as the signal travels in all radial directions, several directional antennas can receive it. This is a point-to-multipoint configuration. It is always important, avoiding or minimizing interferences. Microwaves in the unlicensed 2.4 and 5 GHz frequency bands have a chief importance for WLANs and WPANs. There have been several standards for this (IEEE-802 standards). The original 802.11 standard was introduced in 1997 to operate at 1 and 2 Mbps. Wireless fidelity (Wi-Fi) corresponds to the 802.11b standard, introduced in 1999, operating up to 11 Mbps. In European Telecommunications Standards Institute (ETSI) countries, nominal distances up to 150 m can be reached for free space with line of sight. The newer 802.11g standard, ratified in 2003, operates up to 54 Mbps. The corresponding nominal distance is 100 m. These standards operate in the 2.4 GHz band. The 802.11a standard, approved in 1999, operates up to 54 Mbps as 802.11g, but it uses the 5 GHz band. The respective nominal distance is 70 m. 802.11a has been available in Europe for indoor

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