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- Introduction
  - Push for Home Networking
    - Applications
  - Market Acceptance & Penetration
  - Market Direction
- Technology
  - Powerlines facts & App.
  - Control Network
  - Power Line Technologies
    - Intellon CEBus
      - CEBus & OSI Model
      - Spread Spectrum Technology
    - Echelon LONWork
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      - Architecture
    - Carrier Sense Multiple Access/Collision Detection
    - X 10
    - Plug in
    - Adaptive Networks
      - hybrid token passing media access scheme
- Products
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- Alliances
- Summary

Powerlines Advantages

- Most Ubiquitous Coverage of any media
- More likely to have a power line connection within reach of any home PC than you are a phone jack
  - Each room has “at least” one or two power outlets

Powerlines Advantages

- Multiple power outlets can be found in each room
- AC outlets are ubiquitous in virtually every existing home
- Powerline networking takes advantage of the unused capacity of the power cable to transmit data over the existing home power cabling
- A low cost solution
  - No additional rewiring
- Capable of distributing data as fast as 10 + Mbps

Powerlines Cons

- Noisy environment
- Security issues
- Data attenuation
- Power line based modems are more costly than phone line based modems
- There are regulation issues in some international markets
- Powerlines can not deliver high quality video data

Strengths & Weaknesses

	Strengths	Weaknesses
Power line	Price/Performance AC outlets everywhere Easy connection for non-PC appliances Global Market	Shared media Regulatory issues in some international markets
Phone line	Availability Price/Performance PCs near phone jacks Strong industry Alliance (HomePNA)	Limited number of phone jacks in homes in US, worse internationally US Market Only
Wireless	Only solution for portable devices Common 2.4 GHz band worldwide Industry Alliance (HomeRF WG)	Highest cost Shared Media Fractured market
Ethernet	Lowest cost components Dedicated wiring and bandwidth	Requires new wiring

Noise Sources

- Switching Power Supplies
  - Rich in harmonics
  - Oscillator 20Kh to > 1MHz
  - Conduct oscillator noise onto power line
  - Frequency often varies with load
- Universal series wound motors
  - Vacuum cleaners, kitchen appliances, drills
  - High repetition rate impulses

Noise Sources

- Dimmers
  - Produce large impulses at 100Hz to 120 Hz
  - Large 20V to 50V impulses
- Power line intercoms
  - 3Vpp to 7Vpp from 150KHz to 400KHz
  - Large harmonics
  - About 30KHz bandwidth

Attenuation Sources

- Voltage Dividers
  - Wiring series inductance
  - Shunt loads and EMC capacitors
- Phase coupling loss
- Injection loss
  - Transmitter and coupling circuit output impedance
  - Socket load impedance

Powerline Based Applications

- Industrial
  - Utility Telemetering
  - Automated Storage
  - Factory and Machine Automation
  - Shipboard refrigerated Container Monitoring
- Commercial
  - Point-of-Sale Networks
  - Public Transit Vehicles
  - Residential LAN
  - Vending Machines Monitoring

Powerlines Applications (Power Grids Platform)

- The electric power grid provides a perfect communications platform
  - Most extensive network in the world
  - Extremely robust and modern
  - Long distance signal carriage without regeneration
  - Near light speed propagation, naturally
  - Enormous information carrying capacity
  - No topology limitation

Powerlines Applications (Broadband Access)

- A new revealing technology uses electric power lines for broadband access
- It provides over 1.5 Mbps data access for home users
- The technology uses radio frequencies on top of the mains electricity supply to deliver data
- Access would be gained through electrical outlets, rather than phone lines

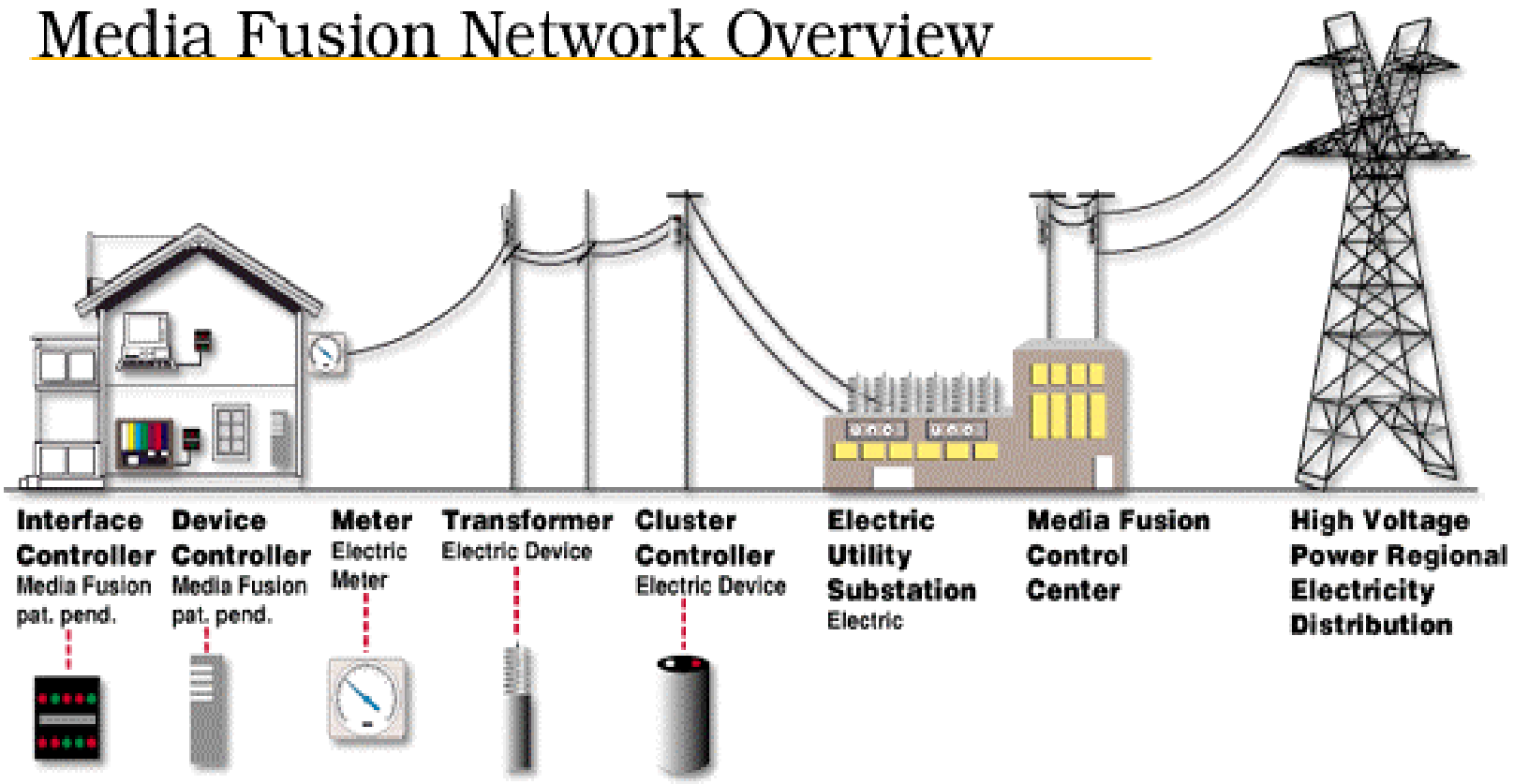
Powerlines Applications (Broadband Access)

- This technology uses a signaling scheme to separate data from electrical interference on the power line
- Allowing users to connect even if power goes out.
- Fiber-optic cabling connected to a central switch carries data between substations and homes

Powerlines Applications (Broadband Access)

- Media Fusion provides voice, data and video communications over the electrical grid at near light speed
- Media Fusion's Sub-Carrier Modulation process writes data within the electrical magnetic wave surrounding the power line
  - Enables the electrical power grid to carry telephone, radio, video, Internet and satellite data to any destination at near light-speed
  - This magnetic field becomes a wave guide in the same way a LASER output uses materials (optics) to amplify or step frequency levels during or after stimulated emission occurs

Media Fusion Network Overview



Courtesy of Media Fusion, Inc.

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What Is A Control Network?

- A control network is any group of devices working in a peer-to-peer fashion to monitor:
  - Sensors
  - Control actuators
  - Communicate reliably
- A control network can also:
  - Manage network operation
  - Provide complete access to network data

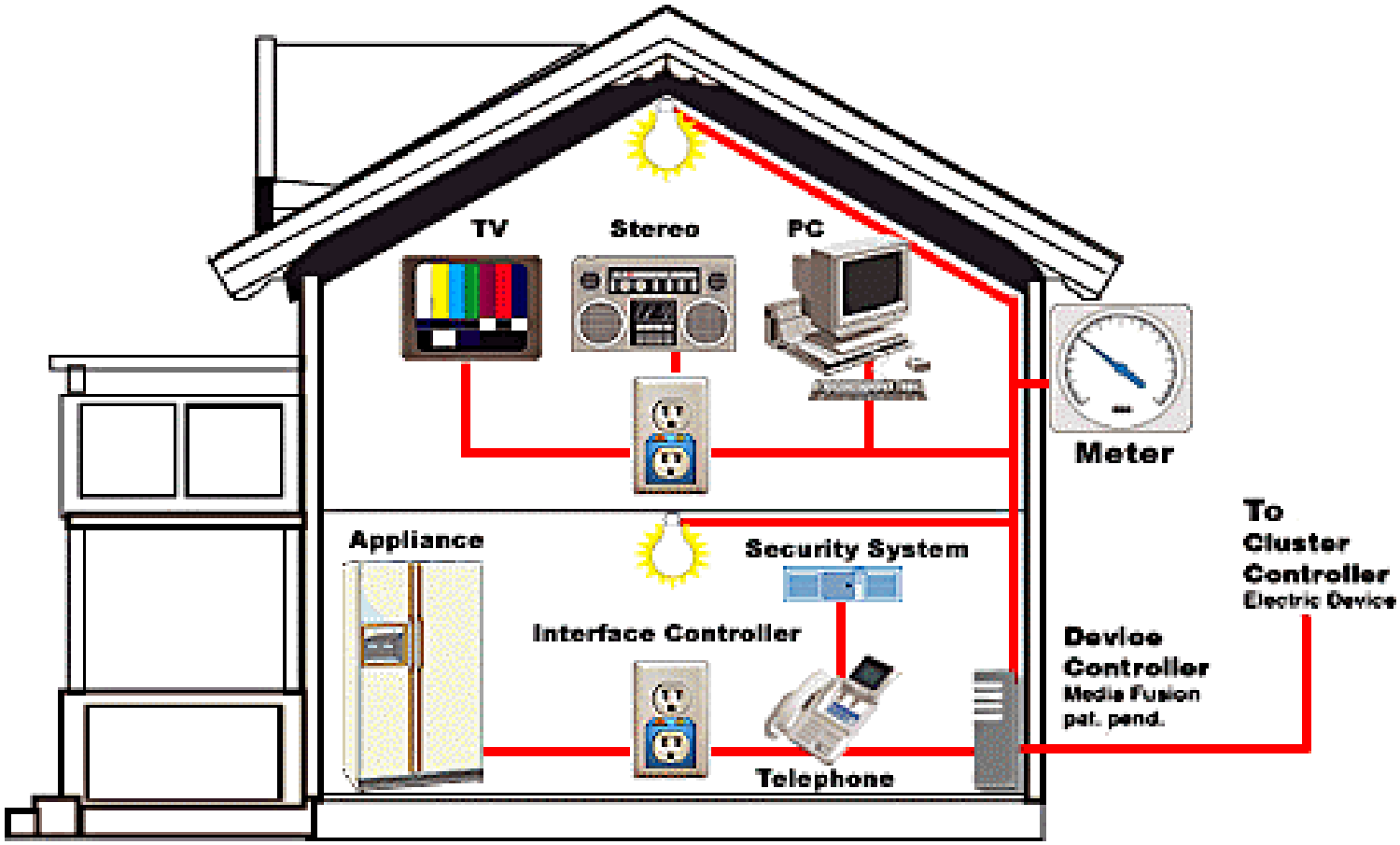
Control Network Platform

- A true end-to-end solution for control networking should offer more than a mere protocol
- A control network platform must address:
  - Interoperability(both at device level and system level)
    - Lower integration
    - Lower installation and maintenance costs
    - Higher system functionality and flexibility
  - Network Operating System
    - A robust, universal platform for installation, configuration, monitoring, and control of networks
    - Software tools interoperability

Control Network Platform

- Seamless integration with IP networks (Internet and Intranet)
  - True end-to-end connectivity between people and devices, using the existing LAN infrastructure
- Easy-to-use application programming environment
  - Programming environment tailored to the needs of control devices and systems as well as the developers
    - more choices in less time
    - Rapid time-to-market
    - Rapid device proliferation
- Infrastructure tools and support
- Routers, Repeaters, PC interface card
- System scalability and flexibility

A Powerline Based Home Network



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Powerline Based Technologies

- X10
  - X-10 controllers send signals over existing AC wiring to receiver modules
  - X-10 technology transmits binary data using the Amplitude Modulation (AM) technique
- Intellon CEBus
  - An open standard which provides separate physical layer specification documents for communication on power lines and other media
  - Data packets are transmitted by the transceiver at about 10 Kilobits per second (Kbps), employing spread spectrum technology

Powerline Based Technologies

- To avoid data collisions, it uses a Carrier Sense Multiple Access/Collision Detection and Resolution (CSMA/CDCR) protocol

- Echelon LONWorks
  - Provides a peer-to-peer communication protocol, implementing Carrier Sense Multiple Access (CSMA) techniques
- Adaptive Networks
  - Utilizes a hybrid token passing media access scheme as opposed to the peer-to- peer CSMA/CDCR schemes
- Intelogis PLUG-IN

Powerline Based Technologies

Technology	X-10	CEBus (EIA IS-60)	LONWorks
Developer	X-10 (USA-Corp.)	Electronics Industry Association (EIA). Further developed by CEBus Industry Council (CIC)	Echelon Corp. Testing and certification programs led by LONMark Interoperability Association
Media Supported	Power lines. X-10 manufactures devices for other media, but there are no standards for them	Power lines Twisted Pair Coaxial Cable RF IR Eventually Fiber Optic	Power line Twisted Pair RF Third party transceivers support
Max. Data Rate	60 bps	10 kbps, Add'l. support for video, audio, and data	610 bps to 1.25 Mbps
Licensing Requirements	Proprietary, company does not license others to use it	Public domain, does not require a license. Certification required to use the CEBus logo	License required. Certification required to use the LONMark logo
Relative Cost	Low	Low to moderate	Low to moderate
Target Applications	Existing and new homes	Existing and new homes	Existing and new homes, commercial and industrial buildings, industrial automation, automotive

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CEBus

- CEBus is a standard proposed by the Electronic Industries Association
- CEBus is an open architecture which explains how to make products communicate through:
  - Power line wires, Low voltage twisted pairs, Coax, Infrared, RF, and Fiber optics
- CEBus based products consist of two components
  - A transceiver which implements spread spectrum technology
  - A controller to run the protocol

CEBus

- The CEBus standard includes commands such as volume up, fast forward, rewind, pause, skip, and temperature up or down 1 degree
- The CEBus Power line Carrier uses Spread Spectrum technology
- The CEBus Power line Carrier spreads its signal over a range from 100Hz to 400Hz during each bit in the packet transmitted
  - Instead of frequency hopping or direct sequence spreading

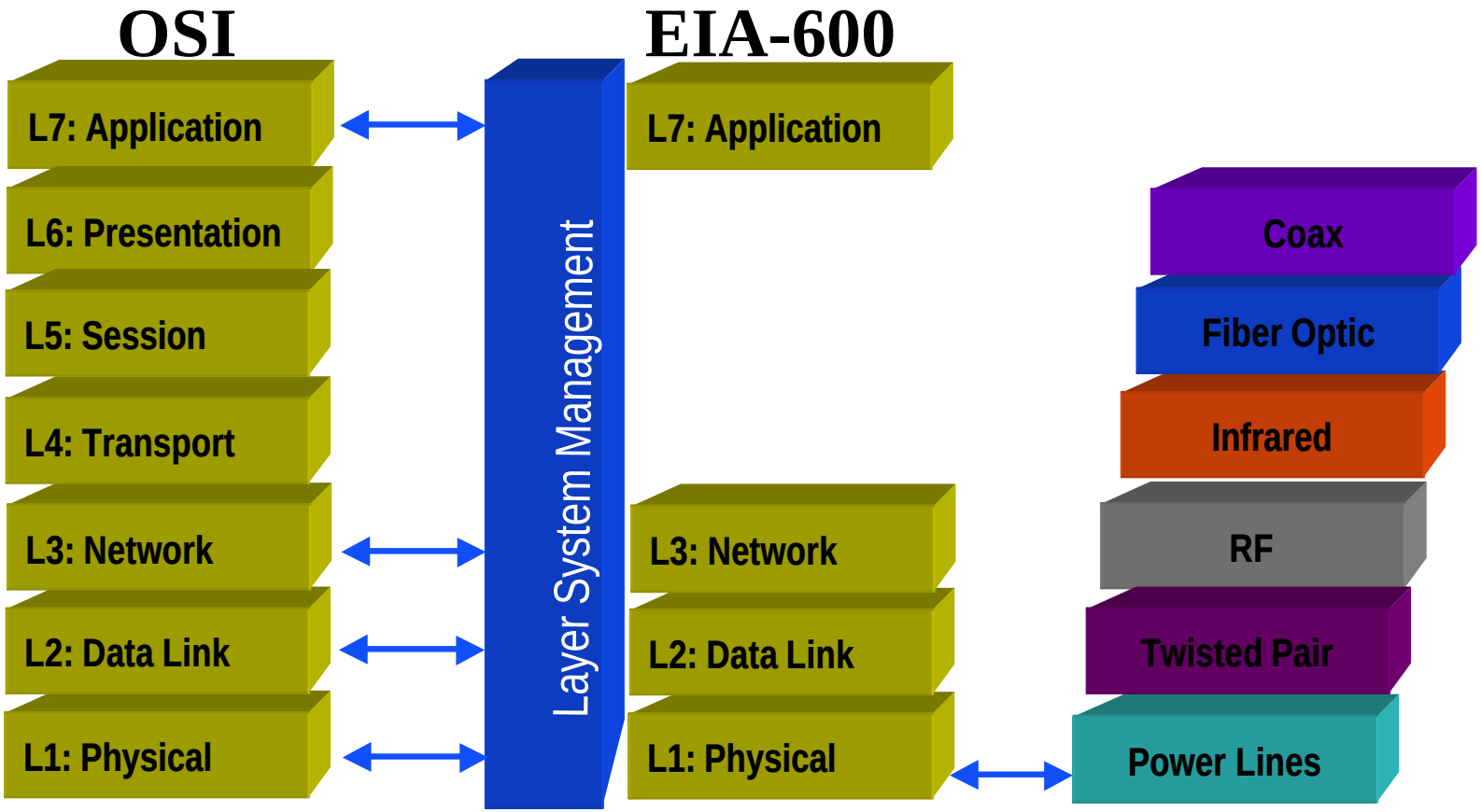
CEBus

- Due to the high noise level of power line channels, data should be transmitted via short frames
  - The requirement for short frames is met by a physical layer spread spectrum technology
  - Each frame is transmitted on a raw data rate of 135 Kbps
- Using forward error correction (FEC) and automatic repeat request (ARQ) transfers data with an effective throughput of 19.2 kbps at an error rate of 10^{-9}

CEBus

- CEBus protocol uses a Carrier Sense Multiple Access/Collision Detection and Resolution (CSMA/CDCR) protocol to avoid data collisions

OSI Model & CEBus



Relationship of OSI model and EIA-600 Model

CEBus & OSI Model

- Application Layer
  - Specifies how service is perceived or experienced by the user
  - Responsible for managing the communication access
- Presentation Layer (Not used by EIA-600)
  - Specifies how the appearance of the service is generated at the user terminal from the telecommunications signal received
  - Provides the services that allow the user to interpret the meaning of the information being transferred

CEBus & OSI Model

- Session Layer (Not used by EIA-600)
  - Specifies how a specific interaction is set up between user and computer
  - Supports the dialog between cooperating users, binding and unbinding them into and out of a communicating relationship
- Transport Layer (Not used by EIA-600)
  - Defines protocol of very general applicability; provides flow control and error control
  - Provides end-to-end control and information/status interchange with the level of reliability and quality of service needed by the user

CEBus & OSI Model

- Network Layer
  - Sets basic standards for formatting of information once link is established
  - Provides the switching and routing functions needed to establish, maintain and terminate connections and data transfer between user
- Physical Layer
  - Provides the characteristics to activate, maintain and deactivate the physical links passing the stream of communications symbols
  - Exchanges symbols with the data link layer, encoding and decoding the symbols to and from the medium states

CEBus & OSI Model

- Data Link Layer
  - Makes a transmission channel appear to the Network Layer as an open, and error-free channel
  - Provides the means for establishing and maintaining individual data links
  - Provides for the transfer of information over the physical link with the required synchronization, error control and flow control functions
  - Provides for the encapsulation and de-encapsulation of the messages exchanged between itself and the network layer
  - Exchanges symbols and medium status between itself and the physical layer

CEBus & OSI Model (Data Link)

- Data from the Network Layer is incorporated into a frame within the Data Link Layer
  - The "frame" is the form of data which is generated within the Data Link Layer
- The contents of the frame are relayed to the Physical Layer for transmission across the channel
- Data received from the channel are passed from the Physical Layer to the Data Link Layer to form the received frame

CEBus & OSI Model (Data Link)

- Data link layer is divided into two sublayers of MAC and LLC
- The Medium Access Control (MAC) Sublayer
  - Performs the functions of transmitting and receiving Protocol Data Units
- The Logical Link Control (LLC) Sublayer
  - Provides the interface to the Network Layer
  - Administers the transmission and reception of Protocol Data Units

OSI Model

OSI Layer	Purpose	Features	Benefits
Physical	Electrical Interconnection	• Support for various media	• Installation • Performance • Reliability
Link	Media Access and Framing	• Democratic media access • scheme and priority • Large Packet size	• Low latency for critical nodes, uniformly democratic access for all other nodes • Support for discrete, analog, as well as configuration and diagnostic data without fragmentation and performance impact
Network	Destination Addressing	• Support for routers	• Size and interconnectivity –support for large networks • Reliability – traffic filtering, segmenting network into functional clusters, while allowing transparent communication across clusters when needed • Installation ease and reliability • Reliability – crating additional paths between communicating nodes
Transport	End-To-End Reliability	• Unacknowledged service, with and without repeat • Acknowledged service • Multi cast service with and without acknowledgment from each node, and the ability to re-transmit selectively • Duplicate detection	• Optimal communication to a large number of devices, or devices unable to acknowledge. Maintains network reliability in these conditions • Reliable delivery • Performance and reliability
Session	Remote Actions	• Request/Response	• Reliability – to ensure acknowledgement of action • Reliability – to ensure sender legitimacy
Presentation	Data Interpretation	• Standard Data type	• Ability to exchange and interpret standard data regardless of applications
Application	Sensor/Actuator Appellation compatibility	• High level standard object interface definitions • Standard configuration properties	• Representation of any sensor , actuator, or controller interface as aggregations of high level objects • Interpretability with standard sensor interface

Spread Spectrum Technology

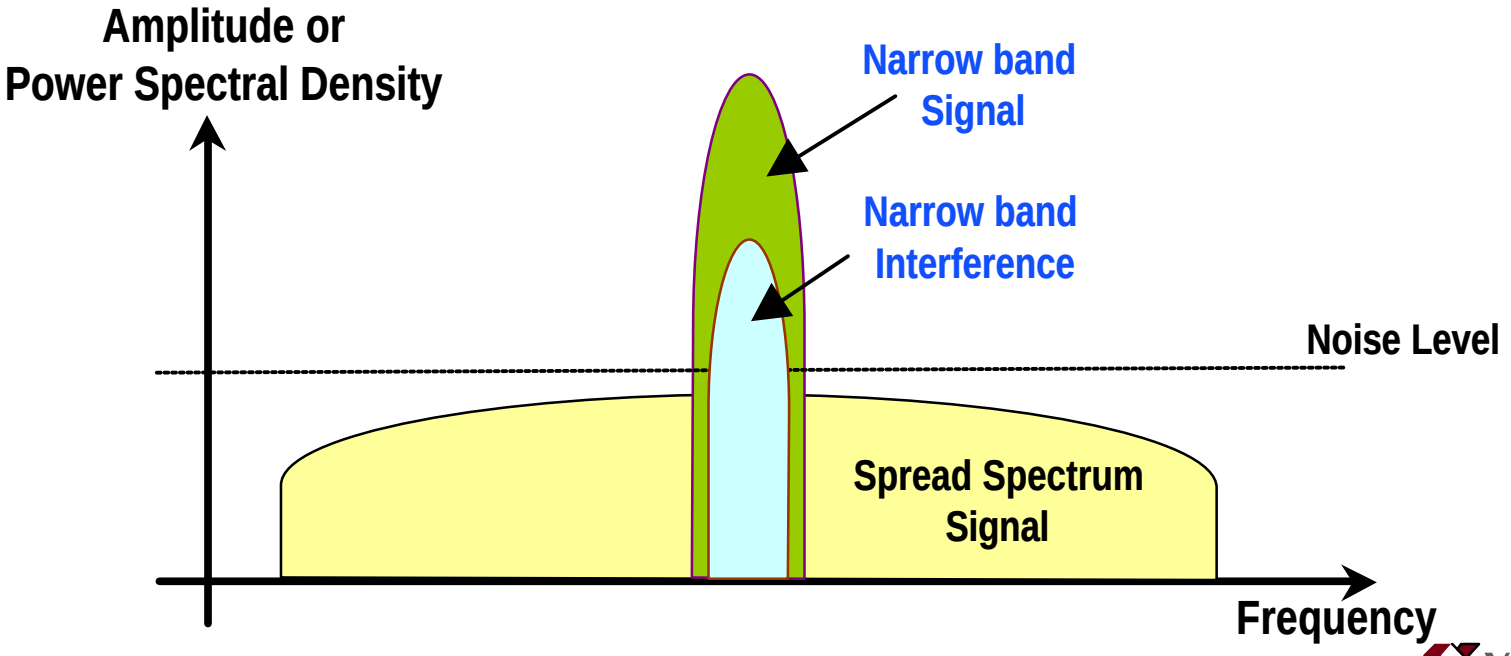
- Physical layer function
- Spread spectrum is a modulation technique of transmission where the
  - The transmitted signal occupies a bandwidth considerably greater than the minimum necessary to send the information
  - Some function other than the information being sent is employed to determine the resulting modulated bandwidth

Spread Spectrum Modulation

- Spreads a signal's power over a wider band of frequencies
- Process gain - sacrificing bandwidth to gain signal-to-noise performance
  - Contradicts the desire to conserve frequency bandwidth
  - Spreading process makes the data signal much less susceptible to electrical noise
- Narrow bandwidth transmission & electrical noise
  - Interfere with a small portion of the spread spectrum signal
  - Result in much less interference & fewer errors when the receiver demodulates the signal

Spread Spectrum Modulation

- Frequency spectrum of a data-signal is spread using a code uncorrelated with that signal
  - Codes used for spreading have low cross-correlation values and are unique to every user
  - Sacrifices bandwidth to gain signal-to-noise performance



Spread Spectrum Advantages

- Low power spectral density
  - Spreading the signal over a large frequency-band makes the power spectral density very small
    - However, the Gaussian noise level increases
- Interference limited operation
  - In all situations the whole frequency-spectrum is used
  - Spread spectrum reduces multi-path effects
- Privacy is kept due to unknown random codes
  - Applied codes are unknown to a hostile user
- Random access possibilities
  - Users can start their transmission at any arbitrary time

How Does Spread Spectrum Work?

- Receivers should be assigned different codes
  - It will address them away from other receivers with different codes
- Codes with low cross correlation properties should be chosen to minimize interference between groups of receivers
- Selective addressing and Code Division Multiple Access (CDMA) are implemented via these codings

How Does Spread Spectrum Work?

- Power spectrum spreads out with spreading the intelligence of a signal over several MHz of spectrum
  - It makes the detection of the none-coded signals very difficult
- By increasing the bandwidth Signal/Noise may be decreased without decreased BER performance

C = W log2 (1+ S/N)

C = Channel capacity in bits

W = Bandwidth in Hertz

S = Signal Power

N = Noise Power

Frequency Hopping SS FHSS

- It works very much like its name implies;Frequency hopping
  - Data signal is modulated with a narrowband carrier signal that hops from frequency to frequency as a function of time over a wide band of frequencies
  - Relies on frequency diversity to combat interference
- This is accomplished by multiple frequencies, code selection & FSK

FHSS Technology

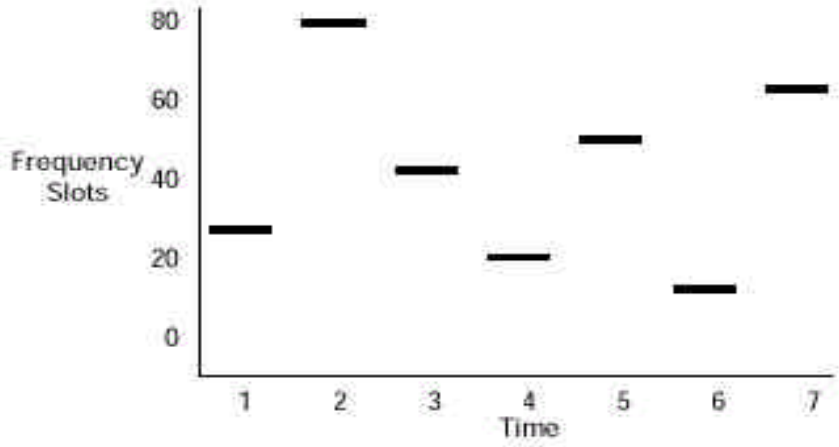
- Hopping code determines the frequencies that should be transmitted and in which order
  - Hopping pattern is known to both transmitter & receiver
    - To properly receive the signal the receiver must be set to the same hopping code & listen to the incoming signal at the right time & correct frequency
  - If properly synchronized the net effect is to maintain a single logical channel
- Unintended receiver sees FHSS to be short-duration impulse noise

FHSS Technology

- FHSS system must hop its whole information signal over a band of frequencies of the ISM band in use
  - Does not interfere with primary user
- Because of the nature of its modulation technique frequency hopping can achieve up to 2Mbps data rates
  - Faster data rates are susceptible to huge number of errors
- Frequency hopping technique reduces interference
  - An interfering signal from a narrowband system will affect the spread spectrum signal only if both are transmitting at the same frequency at the same time
  - Aggregate interference will be very low, resulting in little or no bit errors

FHSS Example for One Channel

- 7 frequency slots exist in the band
  - System send the information signal in frequency slot 24 for the first time slot, then frequency slot 78 for the second time slot, then frequency slot 42 for the third time slot, and so on
- Users wishing to receive signals must tune receiver to particular frequency slot
  - To receiver channel number 1 must tune its receiver to frequency slot 24 for first time slot, frequency slot 78 for the second time slot, then frequency slot 42 for the third time slot, and so on



Different FH Pattern

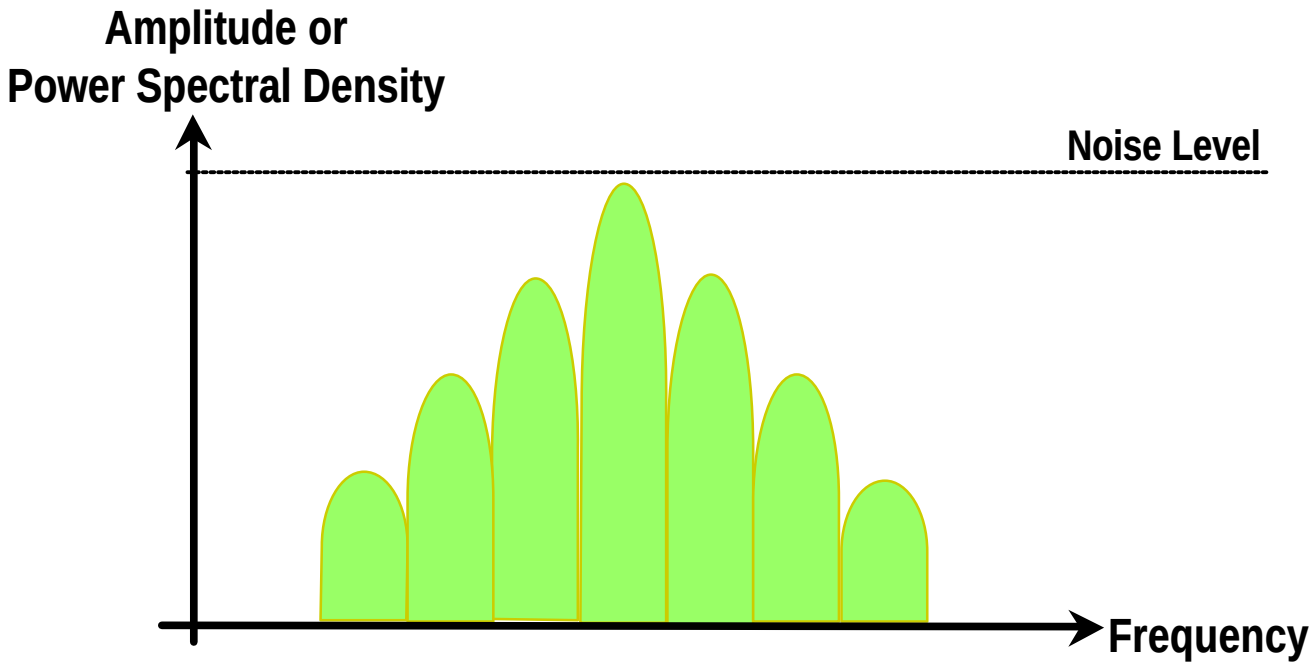
- Each channel is a different frequency hopping pattern
  - Channels are distinguished between channel 1 & channel 2 by having a different frequency hopping pattern
  - Receiver of channel 2 must hop his receiver according to the channel 2 FH pattern
  - This is not a different frequency as in Frequency Division Multiplexing - it is a different Frequency Hopping Pattern

Direct Sequence Spread Spectrum DSSS

- Most widely recognized form of spread spectrum
- The DSSS process is performed by effectively multiplying an RF carrier and a pseudo-noise (PN) digital signal
  - First, the PN code is modulated onto the information signal using one of several modulation techniques (eg. BPSK, QPSK, etc.)
  - Then, a doubly balanced mixer is used to multiply the RF carrier and PN modulated information signal
  - This process causes the RF signal to be replaced with a very wide bandwidth signal with the spectral equivalent of a noise signal

DSSS

- The signals generated with this technique appear as noise in the frequency domain
  - The wide bandwidth provided by the PN code allows the signal power to drop below the noise threshold without loss of information



DSSS
Direct Sequence Spread Spectrum

- Combines a data signal at the sending station with a higher data rate bit sequence
  - High processing gain increases the signal's resistance to interference
- A chipping code is assigned to represent logic 1 and 0 data bits
  - As the data stream is transmitted, the corresponding code is actually sent

Chipping Code: 0 = 11101100011
1 = 00010011100

Data Stream: 101

Transmitted Sequence:

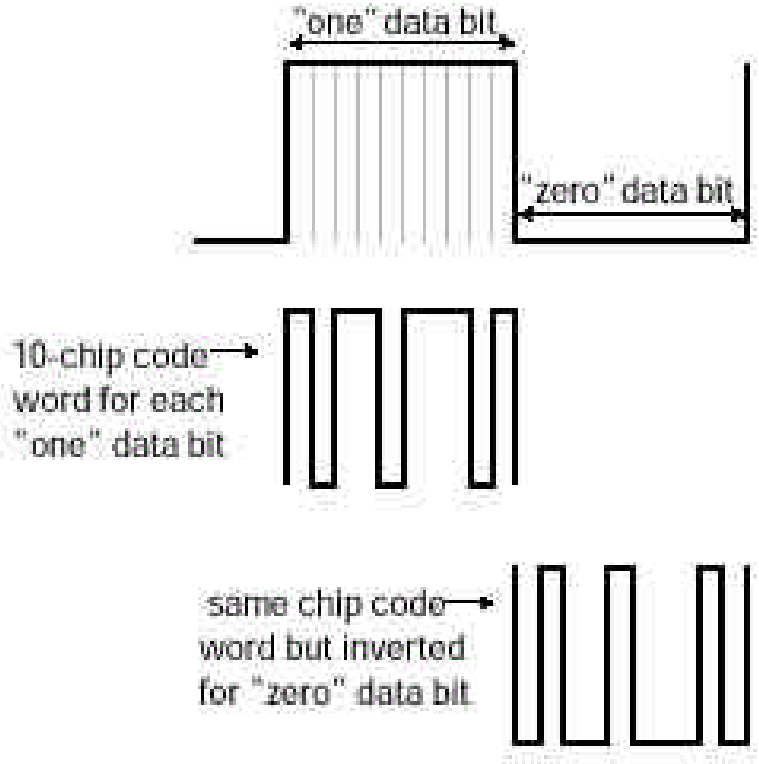
00010011100	11101100011	00010011100
1	0	1

Example: DSSS sends a specific string of bits for each data bit sent - The transmission of a data bit equal to 1 would result in the sequence 00010011100 being sent

DSSS Technology

- Generates redundant bit pattern for each bit to be transmitted
  - This bit pattern is called chip/chipping code (processing gain)
  - Longer the chip
    - Greater is the probability that the original data will be recovered
    - More is the bandwidth that is required
  - If one or more bits are damaged during transmission
    - Statistical techniques embedded in the radio can recover the original data without the need for retransmission
- Unintended receivers
  - View DSSS as a low-power wideband noise & is ignored or rejected by most narrowband receivers

DSSS Technology



DSSS Operation

- Input data stream
  - Runs at 1Mbps
  - Multiplied by a chip stream running 11 times faster at 11 Mcps
- A chip is exactly like a bit - zero or one
  - Called chip only to be distinguished from a bit
  - More chips exist than do bits
- When the bit stream is multiplied, its frequency spectrum becomes spread out
  - Occupies about 11 times as much bandwidth, spectral energy is 11 times lower
  - Since it is so low it does not interfere with the the primary user

DSSS Operation

- With more DSSS systems occupying the band, the overall noise level (interference) rises
  - Causes degradation in performance
  - Causes primary user to increase a bit
    - Increased interference to DSSS users are expected to become a problem long before the primary user notices any interference
- At the receiver
  - Input chip stream is multiplied by the same coded chip stream that was used at the transmitter
  - Two codes are synchronized
    - Original bit stream is correlated
    - Any interference on the air when it goes through the correlator becomes spread out

DSSS vs. FHSS Comparison

Direct Sequence (DS)	Frequency Hopping (FH)
Higher Throughput	Interference immunity
Wider Range	Echo resistant
Upgradeable to higher speeds at 2.4GHz	Less expensive than DS systems
	Simpler installation
	More extensive product selection, more vendors

- FHSS degrades gradually, DSSS degrades drastically!
- DSSS can achieve much higher data rates than FHSS's 2Mbps
- FHSS can have up to 10 or 15 channels, while DSSS can have up to 2 or 3 channels

DSSS vs. FHSS Comparison

- Instantaneous data rates of DSSS can be larger than FHSS
  - In FHSS the maximum bandwidth of the signal is specified to 1MHz at the 2.4GHz band
    - Realistic data rates are limited to 1 or 2 Mbps
  - With DSSS, the rule is to spread by at least a factor of 11
    - Theoretically it is possible to use the whole 80 MHz band & provide a data rate in the order of 6 or 7 Mbps
    - Circuitry would be required to run at a very high rate of 66 or 77 Mbps in order to generate the chip stream necessary to support the 6 or 7 Mbps bit rate
    - This high rate would be very expensive & not seen in the industry at this time

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LONWorks

- LONWORKS(Local Operation Networks) technology is an important new solution for control networks developed by Echelon® Corporation
- A control network is any group of devices working in a peer-to-peer fashion to monitor:
  - sensors
  - control actuators
  - communicate reliably
  - manage network operation
  - and provide complete access to network data
- In some ways, a LONWORKS control network resembles LAN

LONWorks

- It can control and link factory conveyor belts, product inventory, and distribution systems for optimum efficiency and flexibility
- Smart office buildings can turn lights on and off, open and lock doors, start and stop elevators, and connect all functions to a central security system
- Homeowners can program a vast array of products and conveniences, from sprinkler systems to VCRs, with a touch tone phone from any remote location

LONWorks

- LONWORKS technology is a solution for implementing distributed control networks
  - These networks consist of nodes that communicate with one another over a variety of communications media using LonTalk® protocol
    - A common message-based communications protocol
- In a LONWORKS application, nodes sense, monitor, count, measure time, manage switches and relays, and respond to conditions reported by other smart nodes

LONWorks

- The technology of distributed nodes can reduce the amount of wire and number of junctions by one or more orders of magnitude
  - As a result, the network has simpler field installation, increased reliability, and decreased cost
- Since the communications protocol supports different transmission media, such as twisted pair, RF, and power line, the network is extremely flexible

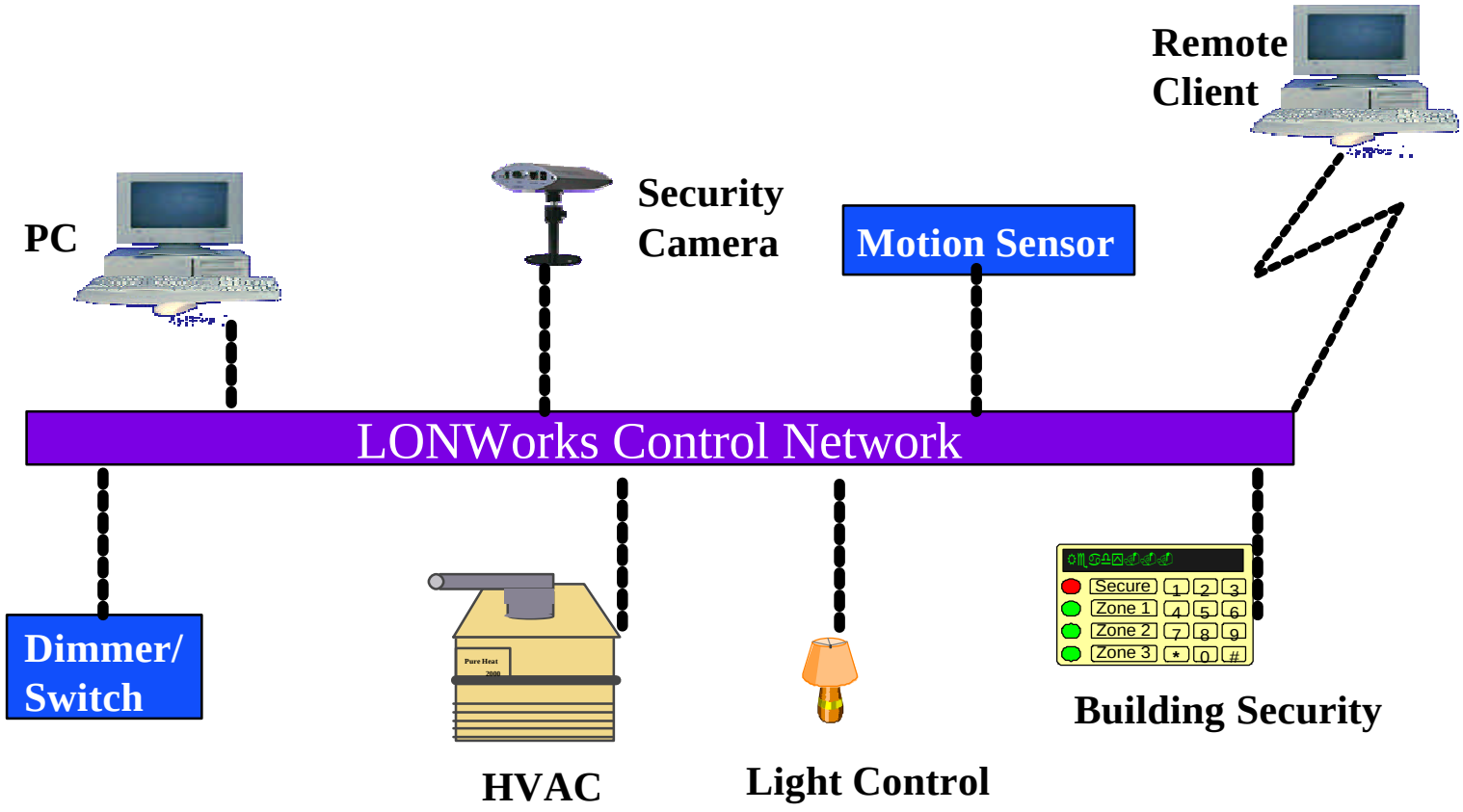
LONWorks Applications

- Appliance Control
- Asset Tracking
- Automated Supermarket Pricing
- Automated Work Environments
- Avionics Instrument Integration
- Circuit Board Diagnostics
- Consumer Electronic Controls
- Discrete and Process Control
- Electronic locks
- Intelligent Industrial I/O Irrigation
- Management, lighting Control
- Liquor Dispensing
- Livestock Management
- Medical Instrumentation
- Office Machine Automation Patient Monitoring
- Power Supply Management
- Research Experiment monitoring

LONWorks Applications

- Vending Machines
- Whole House Automation
- Wire Harness Replacement
- Restaurant Automation
- Security Systems
- Slot Machines
- Traffic Lights
- Utility Meter Reading
- Fire Protection
- HVAC(Heating Ventilation Air Conditioning)Control
- Highway Toll Collection
- Identification Systems
- Elevator Control
- Energy Management
- Environmental Monitoring
- Vehicle Wiring Systems

LONWorks Network



LONTalk Protocol

- It is a common message-based communications protocol
- The LonTalk protocol implements all seven layers of the OSI model
  - Using a mixture of hardware and firmware on a silicon chip
    - thus precluding any possibility of accidental (or intentional!) modification
- The protocol can be run as fast as 20 MHz

LONTalk Protocol

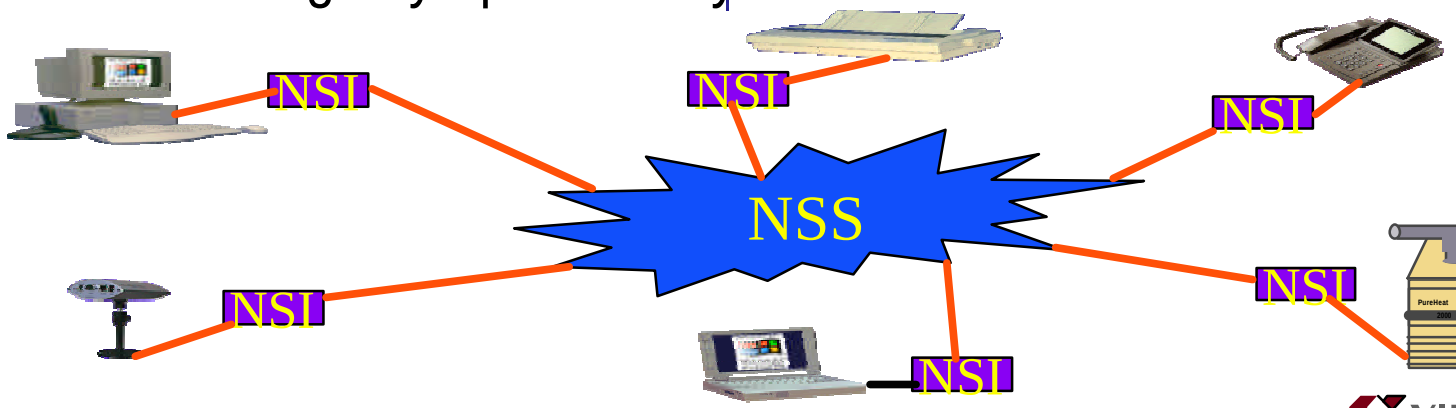
- Features include:
  - **Media Access**
  - **Transaction Acknowledgement**
  - **Peer-to-peer Communication**
  - **Authentication**
  - **Priority transmissions**
  - **Duplicate Message Detection**
  - **Collision Avoidance**
  - **Automatic Retries**
  - **Mixed Data Rates**
  - **Client-server Support**
  - **Foreign Frame Transmission**
  - **Data Type Standardization and Identification**
  - **Unicast/Multicast/Broadcast Addressing**
  - **Mixed Media Support**
  - **Error Detection & Recovery**

LONWorks Network Service (LNS) Architecture

- Services are provided using:
  - Network Service Server (NSS)
  - Network Service Interface (NSI)
- The NSS
  - Process standard network services
  - Maintains the network database
  - Enables and coordinates multiple points of access to its services and data

(LNS) Architecture

- The NSI
  - Provides the physical connection to the network
  - Manages transactions with the NSS and application servers
  - Provides transparent remote access to the NSS and application servers
- Each host is attached to the network using an NSI
  - The host can be any microcontroller, Microprocessor, or PC running any operation system



Carrier Sense Multiple Access with Collision Detect (CSMA/CD)

- When a station has data to send, it first listens to the channel to see if anyone else is transmitting
- If the channel is busy, the station waits until it becomes idle
- A Collision occurs when two stations listen for traffic, hear none, and then transmit simultaneously
  - In This situation, both transmissions are damaged
  - Stations must retransmit at some later time
- Back-off algorithm determines when the colliding stations should retransmit

Variations of CSMA Protocol

- 1- persistent CSMA
  - When a station has frames to transmit, it first listens to the channel, if the channel is idle, the frame is sent
  - If the channel is busy, the station waits and transmit its frame as soon as the channel is id le
  - If a collision occurs, the stations waits a random amount of time and starts all over again
  - The station transmits with a probability of 1 whenever it finds the channel idle

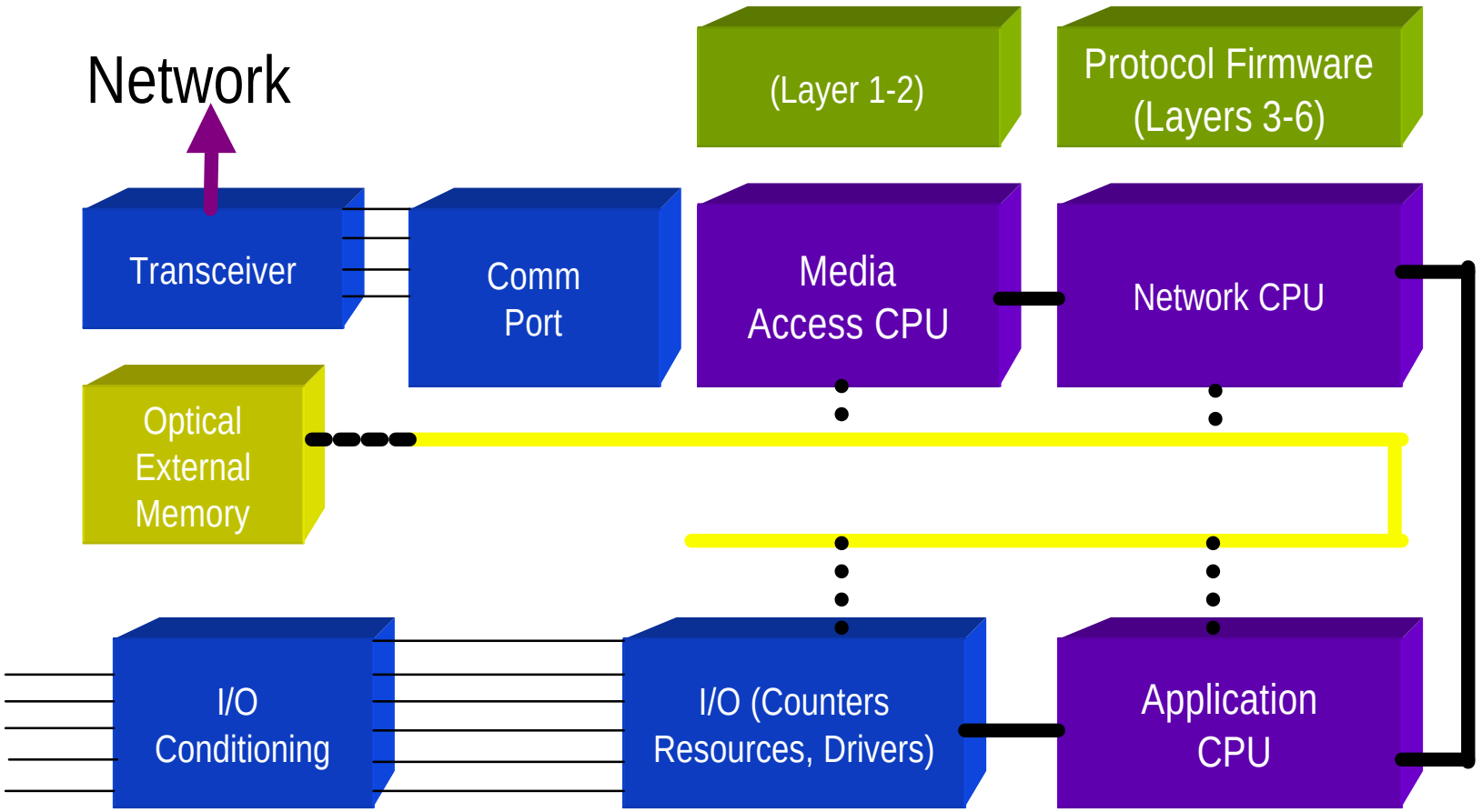
Variations of CSMA Protocol

- Non-persistent CSMA
  - When the channel is busy, the station simply gives up and tries at a later time
- p-persistent CSMA
  - When the channel is busy, the station will keep listening until the channel becomes idle (like 1- persistent)
  - Then the station transmits the frame with a probability of p. The station backs off with the probability of q = 1 - p.

What is a Neuron?

- The Neuron is actually three 8-bit inline processors in one
  - Two are optimized for executing the protocol
  - One is for the node's application
- It is both a network communications processor and an application processor
- Up until recently, all devices on a LONWORKS network required a Neuron

Component Of A LONWorks Device



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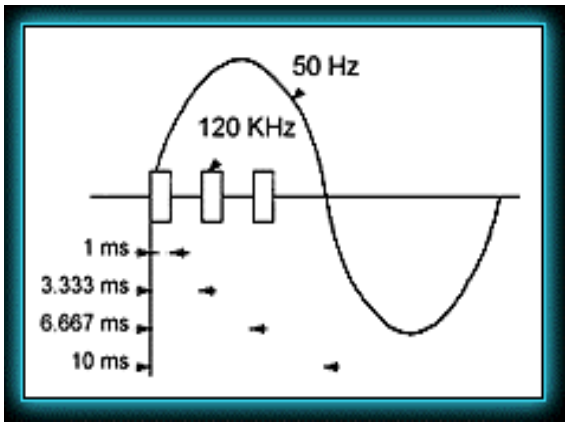
X-10

- Is a powerline carrier protocol
- It allows compatible devices to communicate with each other via the existing 110V wiring in the house
- Transmits binary data using Amplitude Modulation (AM) technique
- X10 is trying to innovate it into higher speed with regard to establish the communication between home PCs and controlled home appliances

X-10

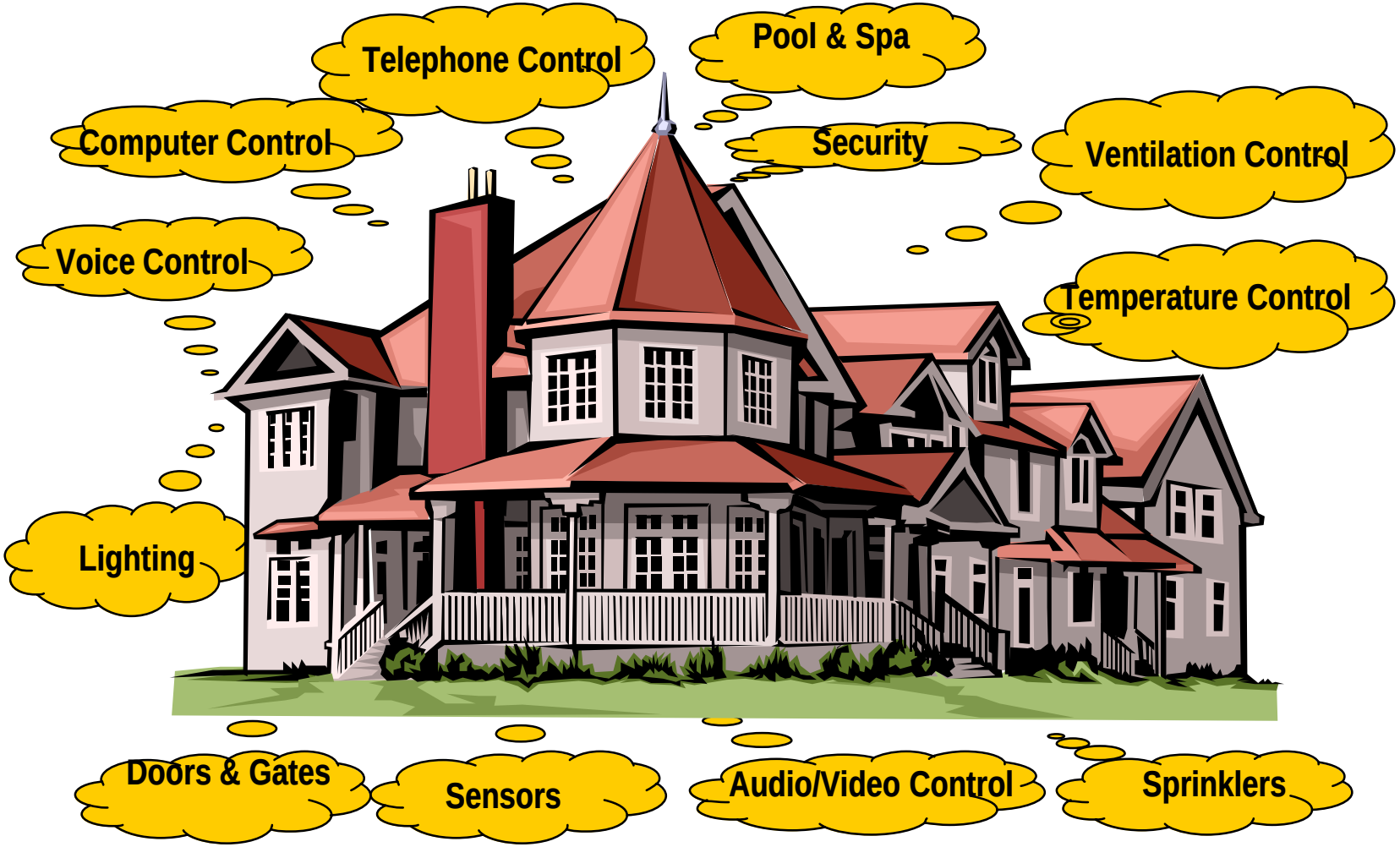
- To differentiate the data symbols, the carrier uses the zero-voltage crossing point of the 60 Hz AC sine wave on the cycle's positive or negative transition
- Synchronized receivers accept the carrier at each zero-crossing point
  - X-10 uses two zero crossings to transmit a binary digit so as to reduce errors



X-10

- Every bit requires a full 60 Hertz cycle and thus the X-10 transmission rate is limited to only 60 bps
- Usually a complete X-10 command consists of two packets with a 3 cycle gap between each packet
  - Each packet contains two identical messages of 11 bits (or 11 cycles) each
  - A complete X-10 command consumes 47 cycles that yields a transmission time of about 0.8

X-10 Applications



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PLUG-IN

- Is a control networking protocol developed by Intelogis
- It is closely related to the Open System Interconnection (OSI) model
  - All OSI layers but the presentation and session layers are defined in the PLUG-IN protocol stack
    - Application Layer - PLUG-IN Common Application Layer (iCAL) Protocol.
    - Network Layer - PLUG-IN Power Line Exchange (PLX) Protocol
    - Transport Layer- PLUG-IN PLX Protocol
    - Data-Link Layer - PLUG-IN PLX Protocol
    - Physical Layer - PLUG-IN Digital Power Line (DPL)

PLUG-IN

- PLUG-IN uses the CEBus Generic Common Application Language as its Application Layer protocol
  - But Intelogis uses a client/server topology instead of the peer-to-peer model
  - Using a client/server topology allows more of the intelligence of each PLUG-IN node' s application to be placed in a centralized Application Server
- PLX defines the MAC portion of the data link layer
  - Uses a MAC protocol consisting of two separate access mechanisms
    - Datagram sensing multiple access (DSMA)
    - Centralized Token Passing (CTP)

PLUG-IN

- PLX protocol also defines rules of operation for the Data Link, Network, and Transport layers
- At the physical layer, DPL protocol uses a modulation methodology called Frequency Shift Keying (FSK) to send digital signals over the power line
  - FSK modulation sends digital signals over the power line by using two or more separate frequencies that are in a fairly narrow band
- PLUG-IN DPL single channel solution boasts line speeds of up to 350 Kilobits (Kbps) per second

PLUG-IN

- The future versions of PLUG-IN DPL will be capable of speeds up to 1 Mbps and beyond
  - Using multiple channels
  - Using carrier signals
- The PLUG-IN FSK modulation scheme delivers bit error rates in the range of 10 -9 with 80 dB of dynamic range

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Adaptive Networks Technology

- Utilizes a hybrid token passing media access scheme
  - As opposed to the peer-to- peer CSMA/CDCR schemes
- A token-passing MAC provides :
  - Reliable transfer of control in a noisy medium
  - Support for multimedia
- It addresses:
  - False synchronization
  - Missed transmissions
  - Near-far problems

Token-Passing MAC

- It ensures only one token holder at any time even in a noisy environment
- Each node receives a transmission subject to different distortion and noise
  - There is the possibility that some nodes will miss a transmission that other nodes hear
- In token passing, nodes cannot transmit unless they hold the token
  - There is no possibility that nodes will transmit during another node's transmission

Token-Passing MAC

- It includes the use of a Token Rotation Time(TRT)
  - The TRT is a fixed value that sets the maximum amount of time a station must wait for the token
  - This value is chosen to balance the worst-case access latency against network bandwidth being consumed for nonproductive token-passing overhead
- When nodes gain access to the network they are limited to their allotted Token Hold Time
  - The THT is the amount of time a station allowed to transmit before it must pass the token to the next station
  - Enforcing THT ensures that all nodes receive their fair allocation of network bandwidth

Token-Passing MAC

- Segmentation and Reassembly (SAR) is integral to the architecture
  - Short power lines frames are derived from segmentation of the typical packet
  - Segmentation into short frames ensures that high-priority traffic is not delayed by maximum-size Ethernet packets