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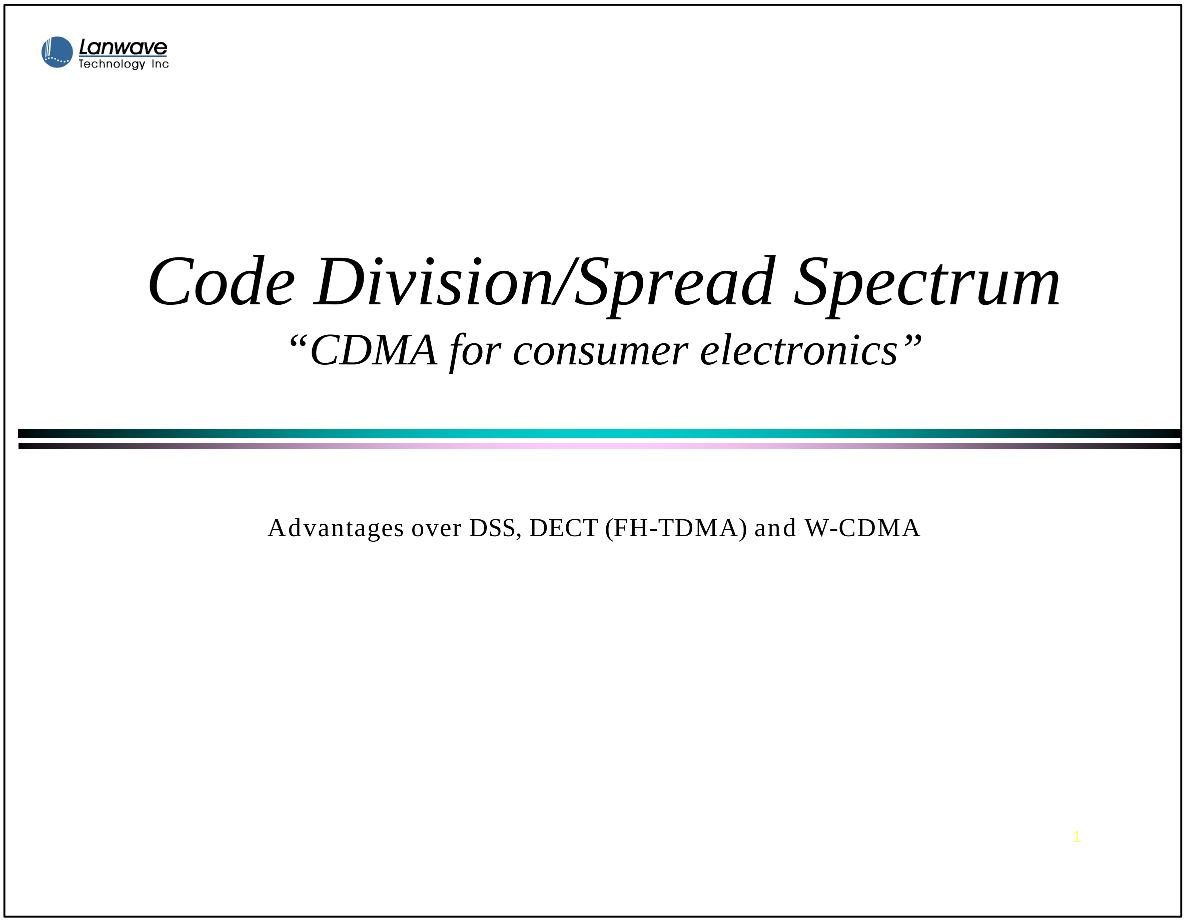
Lanwave Technology, Inc.



Code Division Spread Spectrum is one form of CDMA communication technique optimized for the cost conscious, high volume and short cycle consumer electronics market. Its primary application is in digital cordless telephony today. Meanwhile, it is being applied to wireless devices for the last 100-meter connection to the Internet, and in the wireless local loop to provide sub-$20 handset cost, tariff free mobile voice services in some third world countries.

Why is CD/SS technology suitable for consumer electronics? And how does it compare to other long-range wireless transmission techniques such as DSS, DECT and Wide band CDMA? The next 10 slides will introduce the history, theory and practice, and highlight some technical areas for comparison.

Consumer electronics are, by heritage, an "Open Architecture" market. All forms of technology finds its niche, which eventually help every other technology. This philosophy drives the Lanwave view of this market, and forms the cornerstone to our business approach from sales to research and engineering.

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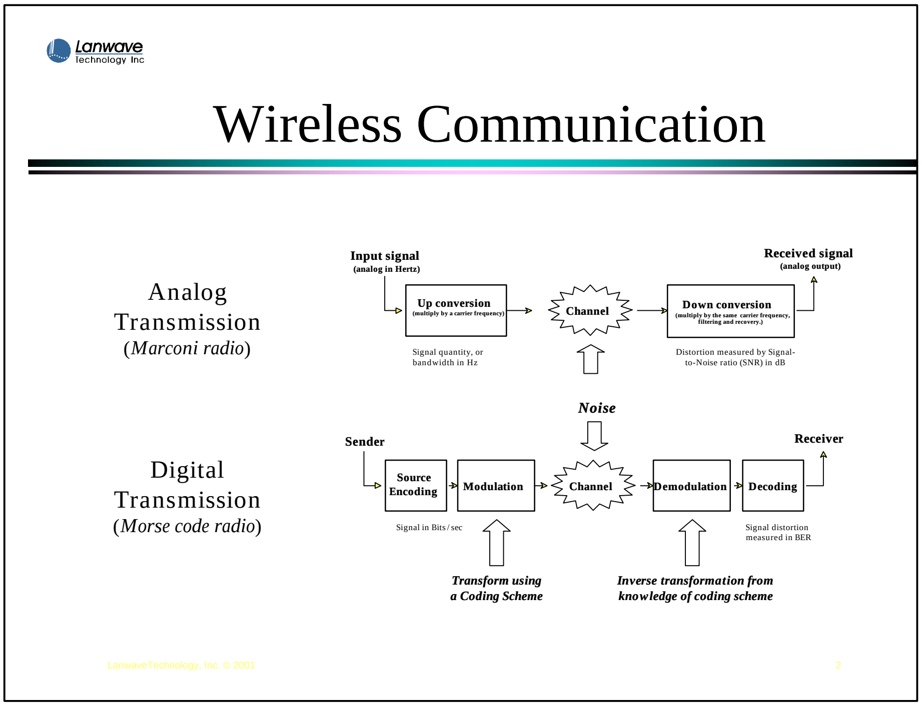

The primary difference between analog and digital transmission is in the addition of a coding engine known as the ***wireless DSP base band chip***. In the cordless phone and similar voice devices, a second ***voice DSP chip*** for source digitization and information compression is used. Lanwave provides both chips and their collateral software to our customers.

As the consumer information sources increasingly turn digital, and device applications increasingly tied to the Internet, digital wireless transmission is becoming necessary, natural and more popular every day, which is not for its performance benefit over analog transmission alone.

The component count, manufacturing cost and engineering, are vastly different in between them. The dichotomy is illustrated by the fact that technology suppliers in this market are largely different and besides solutions from Europe, tends to offer unique and open architecture not yet standardized by committees. However, the consumers and the product channels are the same. So how these digital wireless products shall take advantage of new technology in new solutions to help the consumer; and how they are engineered, manufactured and their benefits told through the channel; become pivotal to the delight and satisfaction of all parties in the supply chain.

So what does digital transmission offer that analog don't? And how do these new abilities bring better solutions to the consumer? Summarized below are 7 unique digital advantages classified under the dictionary definition of *Personal*, *Communication* and *Networking*:

Personal:

1. ***Encrypted*** for exclusive, secured communication.
2. ***Authenticated*** logon preventing interception faults.

Communication:

3. Natural and ***interactive***, full duplex in between parties.
4. ***Multi lingual access*** with voice and data, combined to allow for future service upgrades.
5. Supporting *circuit* and *packet* connection and connectionless ***links*** to the backbone environment.

Network

6. STAR and BUS ***topology***, flexibly supporting point-to-point and point-to-multipoint networking.
7. Open architecture ***protocol***, or system command and control, easily configurable and customizable by the consumer solution designer.

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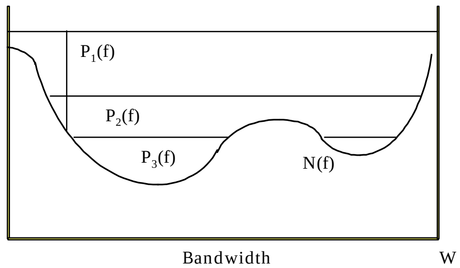
Spread Spectrum Coding

Digital CDMA improves performance over analog transmission



- ***Capacity-maximizing signal density functions*** $P_i(f)$ over available bandwidth W, as a function of frequency f, is the "filling" of the noise density function N(f), such as the situation under uniform gravity. Total volume of the liquid is proportional to the available transmitter power.
- ***Maximum data rate (bit/s):*** $C = W * \log_2(1 + S/N)$ is proportional to signal bandwidth, but logarithmic to signal power. (Shannon et.al, c.1950.)

It has been shown from research, that when the base band DSP chip spreads its signal over a wider bandwidth using the correct ways and means, the resultant transmission performance would be vastly improved over analog and narrow band methods. (C.E. Shannon et. al., since 1950.)

Performance in these cases is measured by the **range**, **security**, **clarity** and **quantity** of information transmitted and received.

The practice of spread spectrum communication in military and aerospace applications has over 50 years of history amongst first world countries. But until 10-years ago this technology was confined by the US Government away from commercial use. Planetary satellites in the transmission of images employed the technology over astronomical distances, while military radar and radios use anti-jamming and anti-eavesdropping communications in the battlefield. Henceforth the ability and robustness of this technology is well proven in non-cost sensitive applications. The challenges today are to commercialize the technology for the consumer electronics market worldwide.

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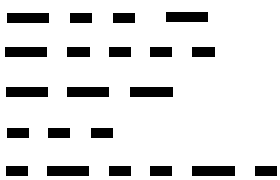
CDMA history

Semaphore (500 years)

- smoke signal
- low bandwidth channel
- long range, low cost
- many drawbacks



Morse Code (100 years)

- EM wave alphabet of dots and dashes
- low implementation cost
- binary amplitude achieve a high noise margin
- high tolerance to phase, time & amplitude jitters
- short code reduces error correction ability

 4

The simplest ways to spreading a signal is by substituting the source signal with a more complex string (phase chopping with a well chosen sequence of code). It is called direct sequence spreading or DSS. This concept has been used for over 500 years in many cultures and situations from the early Indian semaphore to the design of Morse code 100 years ago. Other methods include frequency hopping of the signal around the applicable spectrum. This is the FH-TDMA technique used in European cordless telephone and similar standards.

The earliest means of communication always employ a binary sequence, which tells of the reliability and low requirement of the ***1-bit architecture*** on the fundamental raw material, and therefore solution cost. This binary architecture is still the most suitable for consumer electronics today. It can be shown mathematically that 1-bit quantization may perform as well as other high-resolution methods, and in so doing leaves more room to reducing external RF circuit costs.

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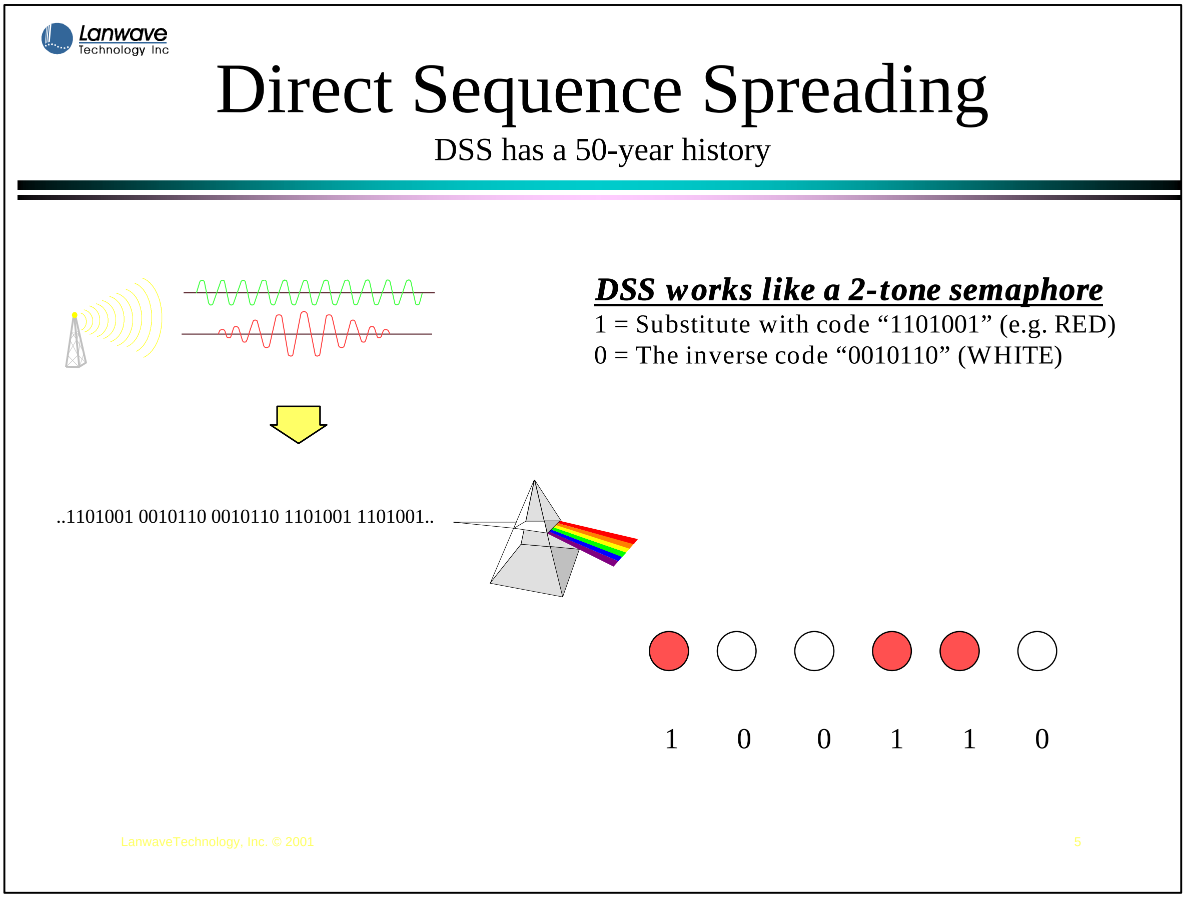

Borrowing the semaphore idea, direct sequence spreading or DSS, can be viewed as the substitution of signal bits by a binary random sequence just long enough to satisfy FCC spectrum requirement to qualify for the use in the unlicensed frequency bands, and yet kept short to limit implementation cost. The most widely used in first generation DSS cordless telephones today employ a 12-bit sequence. The US FCC commercial requirement can be implemented by 10X spread. But due to mathematical reasons the prime number 11 is chosen, and the last 12th bit is used to balancing dc easing RF physical implementation.

Most DSS chips are of relatively low complexity by today’s digital VLSI standards, and therefore DSS phones are able to approach analog telephone costs. However, DSS will not likely match analog raw material cost since a super set of circuit and a higher complexity is being used, absent any business motivated subsidy into the picture.

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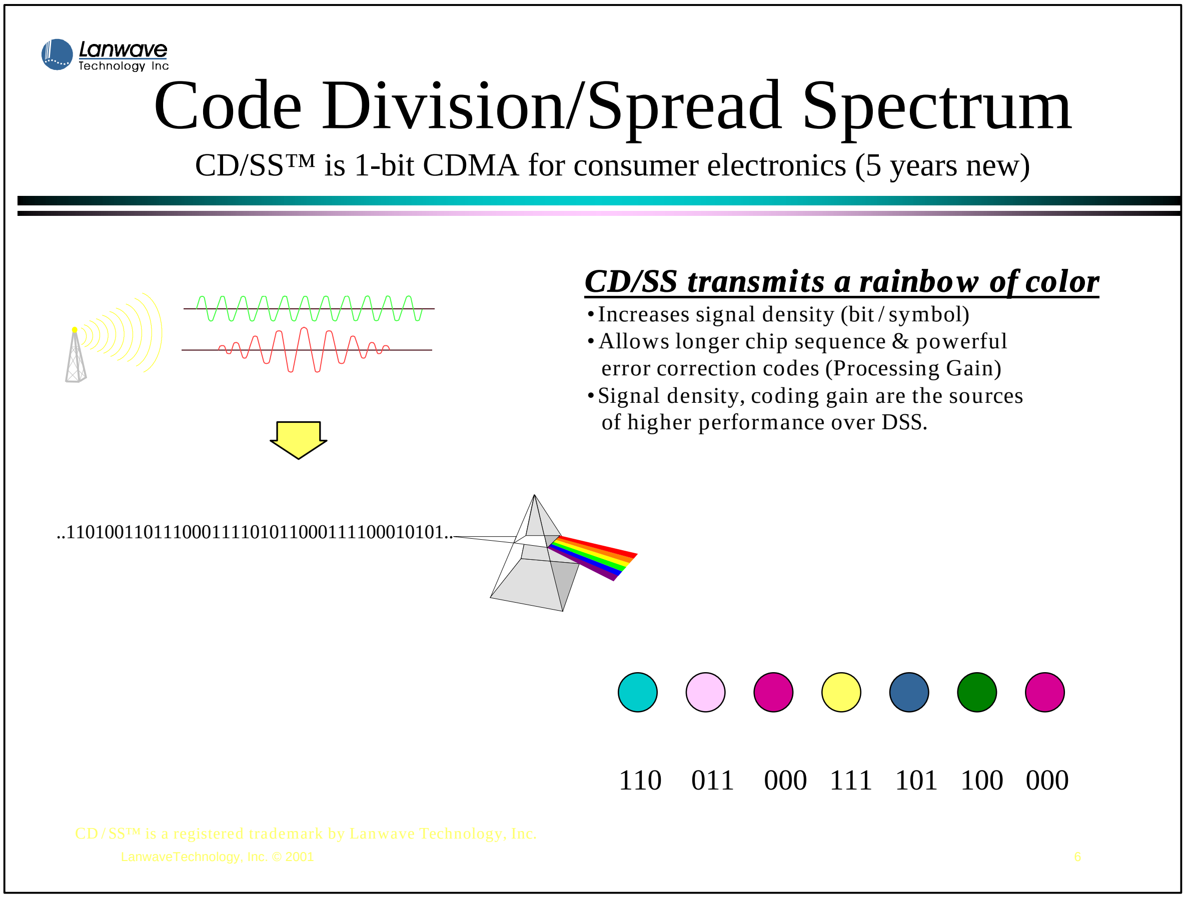

In the CD/SS architecture Lanwave engineers employed a proprietary 1-bit DSP core to keep down cost, and used CDMA techniques to improve performance:

1. Enhance range and clarity with a longer code than DSS (32-bit in the original SATURN chipset version, to 192-bit equivalent in the latest SATURN-II DX family). A long code provides for better error correction ability in a noisy environment. The ability to make correct (color) symbol decisions under random noise is measured in a quantity called ***Processing Gain***. The performance difference between CD/SS and DSS is in between 4 to 10 decibel (dB), before “Link Layer” processing. This roughly translates into a doubling in radio distance when the same class of radio component and transmission power is used. Longer codes also render the communication to be more secure from eavesdropping.

2. Increase signal density by employing 8-level ***Code Division*** technique. In using an 8-level architecture each CD/SS color symbol carries 3 signal bits increasing raw performance over DSS by 300%. However, more coding levels will eventually introduce inter-symbol interferences, and will multiply DSP circuit complexity exponentially. 8-level Code Division was chosen for its optimal balance in between silicon cost and performance using today’s VLSI technology.

3. Adding embedded ***Link Layer*** processing on chip. This enabled a low software complexity. Externally the Lanwave chip set typically requires a 4 to 8-bit class, 4K to 8K ROM, simple micro controller. It is made possible by fully integrating all necessary physical and link layer routines in the on-chip micro code. With embedded software the Lanwave CD/SS chip eases software development and shorten cycle time for subsequent upgrades.

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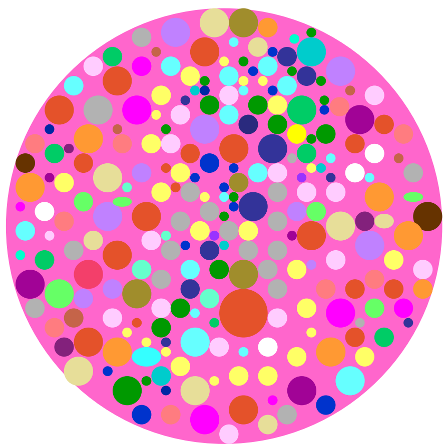
Framing allows for Multiple Access



Do you see the "S" in this picture?

there is an "S" in yellow, an "N" in light gray. When viewing through a pure red filter, the blue and green turns into black reviewing an arrow pointing NE at the one o'clock direction.

The CD/SS color symbols are framed to allow multiple signal messages to communicate within the same spectrum, under external micro controller software control.

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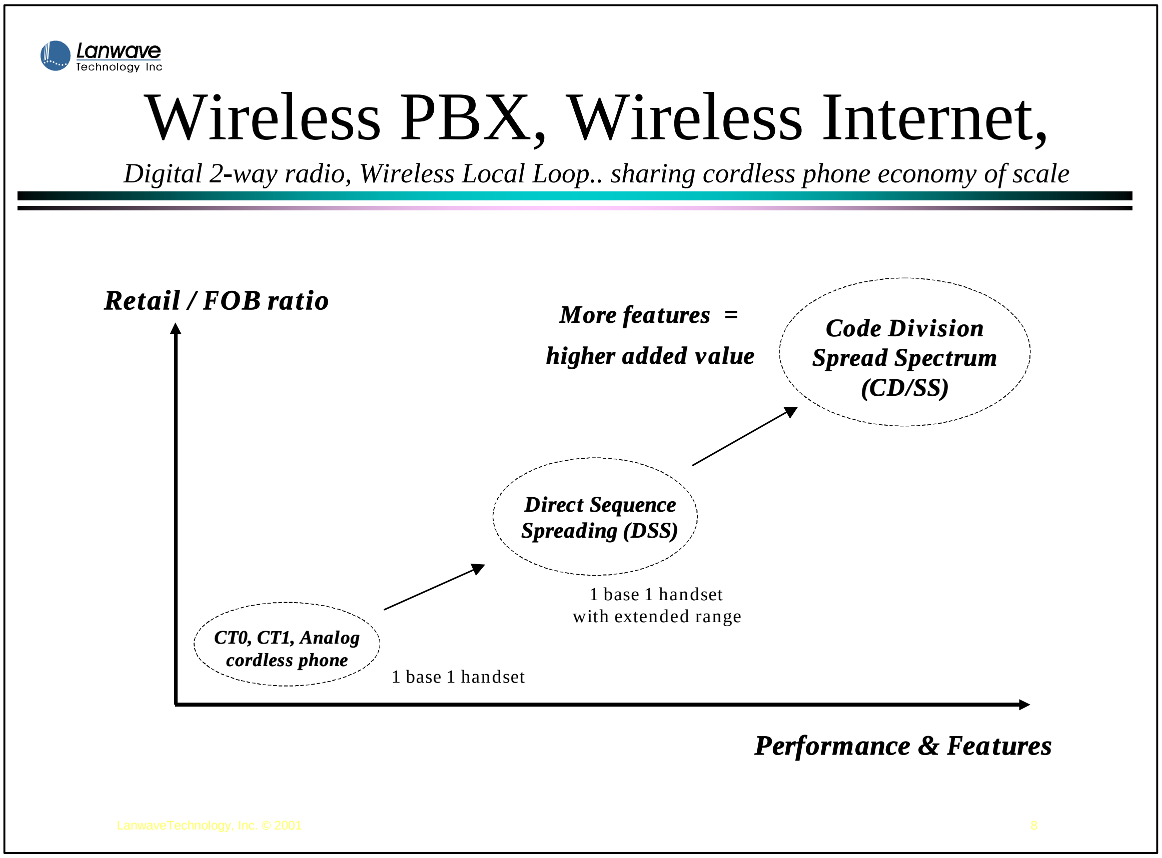

Multiple Access ability enables a cordless telephone designer to readily develop more sophisticated, higher value added products such as wireless PBX, wireless Internet and wireless local loop systems that are more valuable at retail and enjoying a higher manufacturing and distribution margin. Fast upgrade ability enables manufacturers and brand providers to meet the demand of consumers from the home, SOHO to industrial and rural telecommunication market segments. Easy customization allows system manufacturers to build unique, architecture secure and therefore defensible business models and products.

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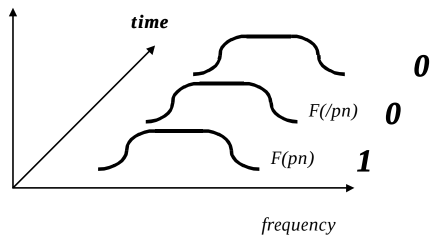
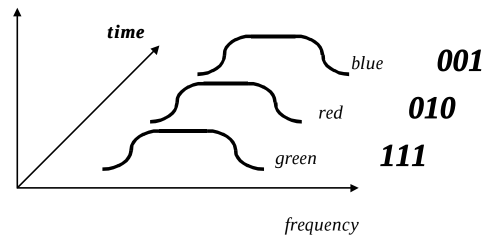
Signal density & RF radio range

Advantage over Direct Sequence Spreading (DSS)

Direct Sequence Spreading
(DSS)



Code Division/Spread Spectrum
(CD/SS & CD/SS with VPSK**)



**** F(pn) is the Discrete Fourier Transform (DFT) of the random code pn.***
***** VPSK (Very Minimal Phase Shift Keying) is adding Pulse Width Modulation on Morse Codes to increase signal density.***

Technically comparing CD/SS with DSS technique:

Empirically CD/SS achieved a 300% signal density over DSS. When a new technique incorporating pulse width modulation is employed (supported in second and third generation Lanwave chip sets), it further improves bandwidth efficiency by an additional factor of 2 (SATURN VX2) to 6 (SATURN DX2). Next generation SATURN chipsets may further increase this factor from the improvement in semiconductor processing technology.

Higher signal density, more error correction and efficient spectrum utilization combined to translate into better radio (RF) sensitivity. The benefit is a longer wireless range for the same transmission power; or reduced power consumption for the same wireless range. Under Link Layer software control these benefits extends usable range and talk time while keep down audio humming. All are direct comparison items in the retail telephone channel, and driving factors for future consumer wireless devices.

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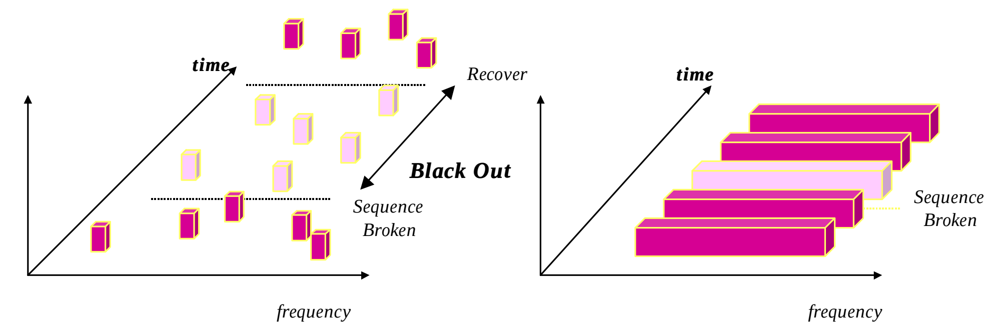
Fast Recovery & Synchronization

Advantage over DECT and Frequency Hopping with TDMA

Frequency Hopping Spread Spectrum
(2.4GHz DECT with FH-TDMA)

Code Division/Spread Spectrum
(CD/SS with VPSK)



- ***Long "BLACK OUT" on FCC required hopping sequences***
- ***Reduces performance exponentially as environment become noisy***

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DECT (short for Digital European Cordless Telephone) employs narrow band, frequency hopping (FH-TDMA) to meet US FCC spectrum requirement in the 2.4GHz range.

Frequency hopping technique is quite different from DSS or CD/SS in many ways. One in particular is that it requires a long recovery period when two communicating parties have lost touch. The process is similar to finding a lost person inside a crowded shopping mall, when both agreed that one would search counter clockwise, and the other clockwise, through each shop. Eventually both parties will meet but this synchronization process may take a long time.

CD/SS technique does not suffer from this problem since its receiver scans every frequency simultaneously (like having a detector inside every shop in this example) and can immediately locate its partner in the next search period. This short recovery ensures that the "Black Out" during which no reception is recorded from the DSP chip can be kept down to a very short duration.

The synchronization problem of FH-TDMA is not limited to DECT, but in all frequency hopping solutions. This problem escalates as the environment becomes more crowded and noisy in the near future.

One other advantage of CD/SS over FH-TDMA is in better RF power tuning. This feature enables a CD/SS DSP chip to calculate the physical and radio distance with its partner, thereby reduces RF transmission power when allowed, and increases only as necessary. It has far-reaching performance implications in improving spectrum capacity and reducing inter system jamming. CD/SS architecture provides a natural facility for the micro controllers to implement a closed loop tuning solution.

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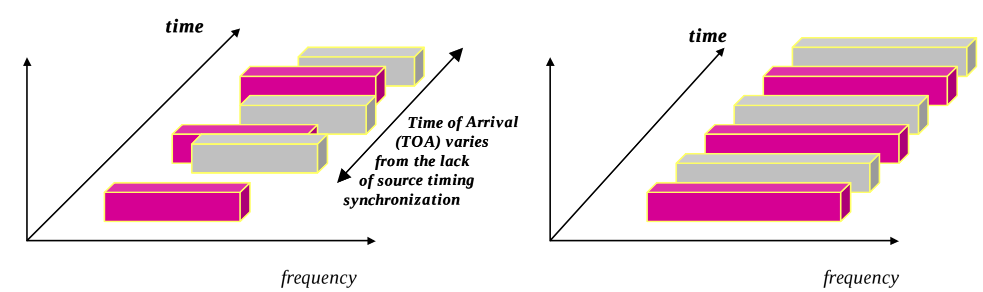
Simplified Code Overlapping

Advantage over traditional CDMA and W-CDMA

Code Division with Multiple Access	**Synchronous *CD/SS***
(CDMA & W-CDMA)	***(S-CD/SS with VPSK)***



- ***Wide variation in "TOA" increases DSP complexity and cost***
- ***S-CD/SS controls code overlap without sacrificing performance***

 11

Technically comparing CD/SS with wide band CDMA, or W-CDMA technique:

Wide band CDMA (W-CDMA) is employed in next generation mobile phone systems. Its advantage is particular to the high-speed roaming requirement of mobile phones.

Because signal arrival time and energy at the receiving antenna is a function of frequency and its interaction with environment objects, a wide band signal has a wider time variation due to multi path effects and Raleigh fading. A special circuit called Rake equalizer is used to compensate for the differential arrival time in the base band DSP. In addition, a packet speech processor is generally employed to allow bursty interruptions from the Rake receiver. Both circuits are not needed in CD/SS architecture. The benefit of code overlap is taken advantage in a synchronous CD/SS design that coordinates transmit timing on multiple code signals.

The reduction in circuit complexity, combined with features such as 1-bit RF quantization reduces the cost of a CD/SS handset to less than one-third of a comparable mobile phone handset. (Less than $20 compared to approximately $60.) And in a typical rural wireless local loop environment the advantage in Rake receiver compensation is not needed, and hardly justifiable by a 3 times increase in unit cost.

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Spectrum Performance

	Hertz/bit/second	Coding Gain
	=============	==========
DSS (12-chip, BPSK)	18 Hz / b/s	11 dB
CD/SS (GMSK, TDD full duplex)		
- Gen 1 (VX), obsoleted.	32 Hz / b/s	15 dB
- Gen 2 (VX2)	16 Hz / b/s	15 dB
- Gen 3 (DX2)	5 Hz / b/s	10 - 12 dB
G3 un-spread mode	3 Hz / b/s	0 dB
G3 un-spread burst mode	1.5 Hz/b/s	0 dB
Manchester Coding	6 Hz / b/s	0 dB
DECT /FH-TDMA	3 Hz / b/s	0 dB
Narrow Band Digital	3 - 6 Hz / b/s	0 dB

These figures are calculated using the most typical RF implementation.

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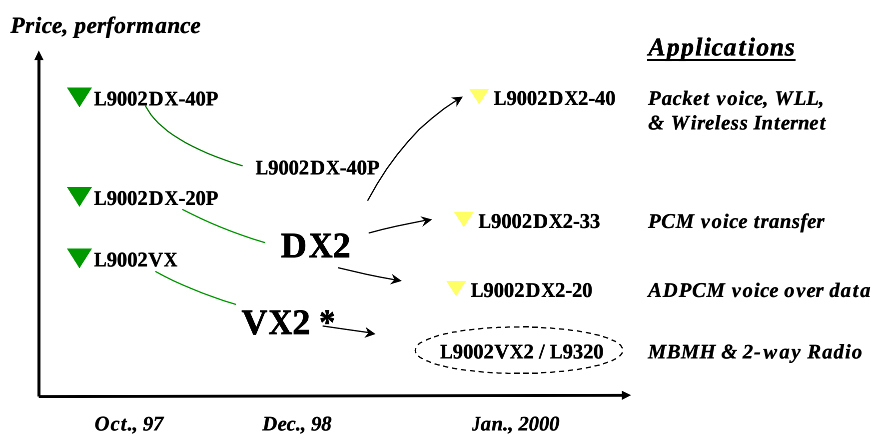
3rd Generation CD/SS chipset



All SATURN chip families are backward software compatible at the binary code level. This protects customer software investment and allows short R&D cycle time after the initial CD/SS product has been engineered and introduced.

-- END --