Computers and Media: History of Media and Technology

CSCI 1200
JAREK SZLICHTA

Goals

Today we will begin our review of the history of media and technology with an overview.

Related Readings: Chapters 2, 7 and 8.

History of Media and Technology

Why does the history matter?

Can we get by just fine without knowing about ancient media, the development of hieroglyphs or printing press?

Why does history matter?

Many of the legacy media are still around:

- books, newspapers, magazines, tv, radio, motion pictures

Many of the differences are derived from what came before

To truly understand the nature of the Internet, you have to understand the history of radio

The Dawn of the Digital Age

Agrarian Age - until the Industrial Revolution in the 1800s, societies existed with a high dependence on agriculture – you lived on what you raised (vegetables and animals).

Industrial Revolution - societies changed and technologies allowed manufacturing and the development of factories

Information Age - with the advancement of communication technologies in the 1900s, society saw the arrival of an information age in the 1980s where more individuals became workers in the field of information.

Information Society - thanks to the digital revolution, we exist in an information society where individuals have greater access to information.

History of the Digital Revolution

Marshall McLuhan, the global village

- Idea from the 1960s
- His idea was that individuals everywhere would share information
- Today, this seems very simple; in the 1960s, it seemed virtually impossible

The Early Days, 1970s-1980s

- Military and education adopt the Internet

Boom and Bust, 1994-1999

- Society embraces and becomes oversaturated
- Over-valued stock prices created a ''dot-com bubble', that burst around 1999

Reemergence, 2002-

- High speed Internet and smart phones push resurgence

Forces Influencing the Revolution

Economic

- Economic forces encourage innovation, though some media (newspapers) resist change due to economic concerns

Technological Innovation

- Creative individuals with ability and identified needs

Government and Legal

- Regulation to encourage development (or erect barriers)

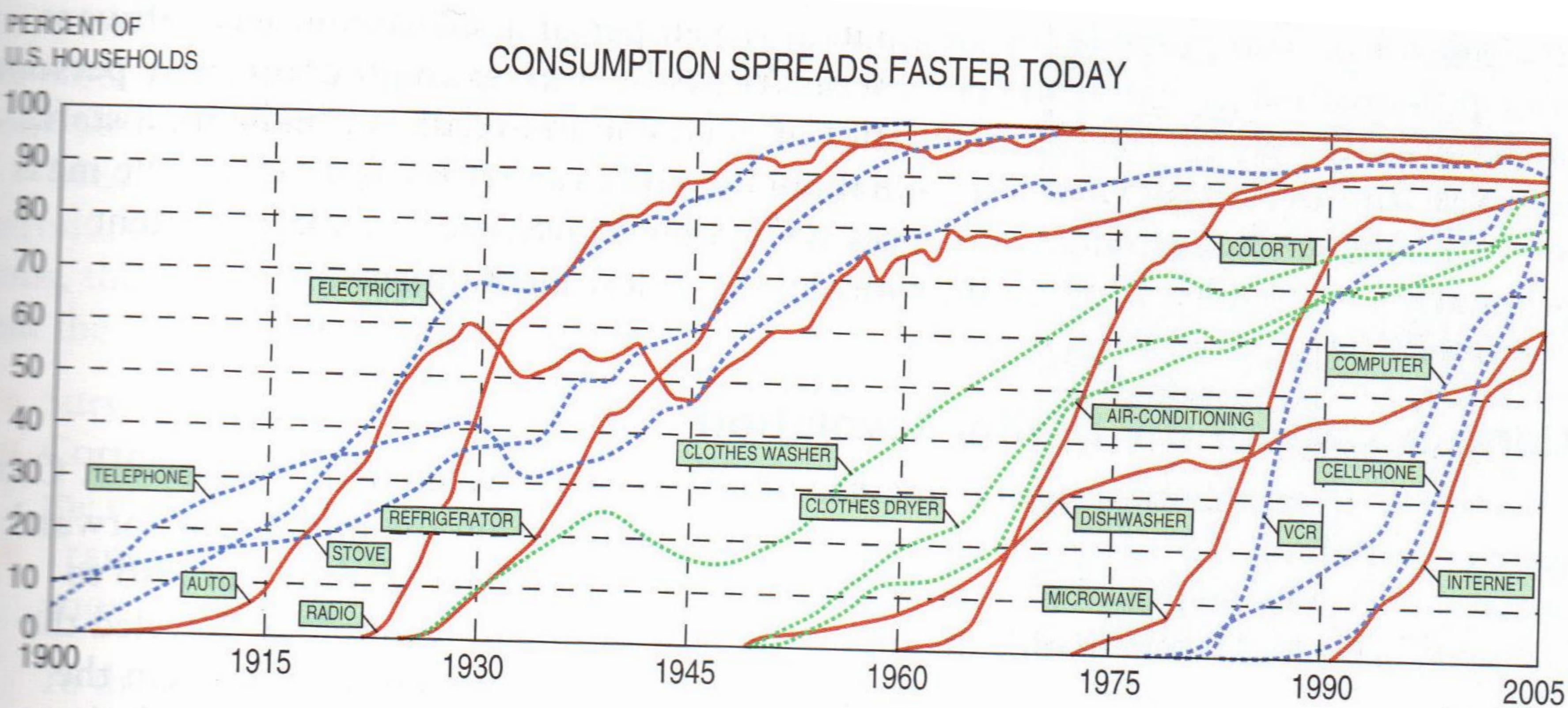
The Speed of Change in a Digital Age

Adopting Technological Innovations

Diffusion of innovations is a theory that seeks to explain how, why, and at what rate new ideas and technology spread through cultures.

Diffusion of Innovation (Rogers & Shoemaker, 1971)

- innovation
- adoption
- adoption curve



Source: "Week in Review" *New York Times*, Feb. 10, 2008, p. 14; see also W. Michael Coz and Richard Alm, "You are What You Spend," also p. 14.

Where are you on the curve?

Smart phone?

Tablet computing?

Blu-ray?

Gaming console?

Blog/vlog?

The world is flat.

Digital Revolution

Thomas Friedman “The World is flat”.

Pros:

- New technology more widespread, available to more and more people
- Mass communication available to everyone

Darker side:

- concerns of privacy
- cyber crime
- decline of quality media that had evolved over 200 years

Case Study: Paper

MEDIA & TECHNOLOGY

Paper Spreads Writing

Paper making technology and the printing press made print media possible

Before paper writing was difficult and time consuming, more like carving than writing

Paper made writing with ink possible, much easier and faster

Books by Hand

Books were copied by hand, so multiple copies of books were possible, but the process was quite slow..

Libraries of standard books, the knowledge of the world

This lead to universities and centres of learning

But producing books was very expensive, only the very rich could afford their own books

Printing Press

A printing press could produce a page in just minutes or seconds, instead of hours or days, through a mechanical process

Implications:

- Standard printing fonts were developed, much more readable than hand writing
- The spelling of the English language was standardized, before the printing press there were often multiple ways of spelling a word

Impacts

This greatly increased the literacy rate: a gentleman of the age was expected to be able to read

Resulted in greater demand for books, which further increased literacy, …

By the 1800s newspapers were becoming popular in the western world, the main source of news into the 1960s

Changed Society

We now expect virtually everyone to be able to read and write

Reading and writing was possible more than 3000 years ago, but it was not until the technology of paper and the printing press became available that it become common practice

With printing authors could produce popular works without knowing how to run a printing press, but they needed to understand the implications of printing technology

Authors View of a Printing Press

Authors needed to understand:

- Standard fonts, cannot use fancy writing styles
- Pictures were expensive, particularly colour
- Some illustration styles were cheaper than others

Recent developments in printing technology have removed these restrictions.

However, the art of writing had already been established, the format is well established and most writers follow it

Understanding Technology from a Media Viewpoint

We need to understand how the technology works, but not necessarily how to use it, how to program the computer

Like the author that understands the printing process but does not run the printing press..

Introduction

In this part of the course we will examine the technology used in modern media

Use this to understand different types of media, the production process, and how it is distributed

Without this background media seems like magic, cannot predict the future, what is possible and impossible

Analog Media

MEDIA TECHNOLOGIES

Analog Media

The first media revolution was based on analog media

This type of media is slowly dying out, but its important to understand its properties, how the switch to digital media impacts the media industry

All of the mass media forms used to be *analog*, it was the standard approach.

Analog Media: Make Copies

Analog media can be used to make an exact copy or replica of a media object in another form

- earliest example is printing

In an early form of printing a wood block was carved in the form of the final printed page

Ink was spread over the block and it was then pressed against a piece of paper to print the page

Once the wood block was carved it was easy to produce many copies of it

Movable Type

Carving a book one page at a time was a time consuming and expensive process..

Movable type was the major advance in printing technology

In this process individual metal type, each with a single character on it, is the basic unit of printing

Each page of text consists of lines of type, with each line consisting of individual characters


abcdefgh
ijklmnopq
rstuvwxyz

Analog Media

A line of type is constructed by selecting the individual type pieces with the required characters and assembling them along a rail

When the line is complete the rail is closed and the printer goes to the next line

A line of text can easily be assembled, sort of like using Lego

With this process printers did not need artistic skills

Automating Typesetting

Movable type first appear around 1600 and was used up into the middle of the 1900s

Machines were invented to automate the process, including typesetting machines with keyboards

Printing press terminology, such as fonts and points, are still used today in the digital printing process

Sound Recording

Another good example of analog media is sound recording

Sound is produced by changes in air pressure, we make the air vibrate

The rate at which the air vibrates is called the frequency and is measured in Hertz

- which is the number of vibrations per second

We hear from basically 40 Hz to 24 KHz, the exact range is the subject of debate, but this is a safe range

Wax Cylinder Recording

The first sound recording were made on wax cylinders

Wax is a soft material and it is easy to scratch the surface of a wax cylinder

The recording device consisted of a spinning wax cylinder that was connected to a needle

The needle was vibrated by the sound waves and scratched the surface of the wax cylinder producing a pattern that matched the sound wave

Analog Media

Playing Analog Sound

Examining the surface of the wax cylinder reveals a pattern that is an exact copy of the sound waves

To play the recording a similar method is used, but in this case the needle is connected to a thin material that vibrates as the needle moves over the surface of the wax cylinder

These vibrations will produce a sound which is the same as the recorded sound

Move to Vinyl

Over the years sound recording technology has improved with microphones, speakers and amplifiers, but up until the 1980s this was the basic technique used to record sound

This illustrates the basic principle of analog media, the sound was copied onto wax, later vinyl was used

A True Copy

Sound recording illustrates some of the important properties of analog media

We get a complete copy of the sound, everything in the sound wave is copied

The only limitations are due to the mechanical properties of the devices there are no other limiting factors

Some serious *audiophiles* still prefer analog recordings for this purpose (no loss of information due to digital encoding)

Problems with Analog Media

Each time we make a recording, or copy a recording we introduce some noise

In reality we do not get an exact copy, a little bit of noise is introduced into the copy

This is usually due to imperfections in the *devices* used to make the copy, or sometimes the *environment* in which the copy is made

Reducing Noise

Reduce sequential copies (copy of a copy effect)

In the case of vinyl records a printing like process is used, the records are stamped out from a master in the same way that a page is printed on a printing press

Vinyl records are produced on an assembly line that stamp them out

Copying Film

In film photography a chemical process is used to produce the picture

A plastic material is covered in chemical that reacts when they are exposed to light

Another chemical process is used to transfer the image to paper

The quality of the images depends upon the chemicals used and how uniformly they are distributed over the film

TV

TV also used an analog process, but now process is totally electronic

Digital TV is now commonplace

Summary

We:

- Began to explore the history and media and technology
- Focus on analog technology

I am sitting in a room.

Alvin Lucier, 1969

http://www.ubu.com/sound/lucier.html

"I am sitting in a room different from the one you are in now. I am recording the sound of my speaking voice and I am going to play it back into the room again and again until the resonant frequencies of the room reinforce themselves so that any semblance of my speech, with perhaps the exception of rhythm, is destroyed. What you will hear, then, are the natural resonant frequencies of the room articulated by speech. I regard this activity not so much as a demonstration of a physical fact, but more as a way to smooth out any irregularities my speech might have."

I am sitting in a video room.

Patrick Canoza, 2009

http://www.youtube.com/watch?v=icruGcSsPp0

Comparing the Errors

Analog

- Resonance
- Reflection
- Noise

Digital

- Encoding
- Compression

Goals

We will continue our review of the history of media and technology with an overview of:

- digital media
- text representations in digital form
- sampling
- compression

Digital Media

MEDIA TECHNOLOGIES

Digital Media

The information is encoded as discrete numbers

Not an exact copy, an approximation

Most media are now digital

We need to understand the implications of the switch to digital

Digital Representations

Digital representations are used in both computers and communications networks

In traditional information theory the basic unit of information is the bit

The bit was used in information theory before it was used in computers

Information theory was developed at Bell Labs

- to assist with the design of telephone networks

Early Digital Representations

Early computers, up into the 1960s, used decimal arithmetic

They borrowed their arithmetic circuits from electronic calculators, which used the decimal system

IBM 1620

One of the last computers to use decimal arithmetic, the last one was sold in November 1970

About Bits

A bit can have only two values, which are usually called 0 and 1

- a bit on its own really stores very little information, just a yes or no answer

To store anything significant we need to put multiple bits together

The next unit of information is the byte, which is 8 bits long

With a byte we can represent 256 different values

Bits and Bytes

The byte was popularized by IBM and several communications companies

256 values were enough to represent printed text, plus a set of codes that were used to control typewriters

Business Drives Innovation

IBM started as a typewriter company, and typewriters were an important business unit until at least 1980

IBM started building computers as a side line, mainly for advertising, to show how sophisticated they were

No Mandarin or Farsi Bytes

The byte represents a cultural implication of digital media

256 values is more than enough to represent all the characters in Western languages, but what about Asian languages?

Early computer technology was developed mainly in North America, and in Europe, so they really were not concerned about Asian languages

For Asian languages we need to use 16 bits to represent most of the characters

Some Need Two Bytes

Whether we like it or not, the byte has become the main unit of storage in computers, a 16 bit character is just two bytes

It is also the main unit of information transfer between digital devices

We also use the base 2 system for all units of size in digital media

1024 or 1000?

A kilo byte, or Kb is 1024 bytes

- We usually say a Kbyte is a thousand bytes, but its really the closest power of 2 to one thousand, $2^{10} = 1024$

Similarly a mega byte or Mb is really 1048576, or a bit more than a million

A giga byte or Gb is a little more than a billion bytes

Most of the time we ignore these differences

The benefits of binary

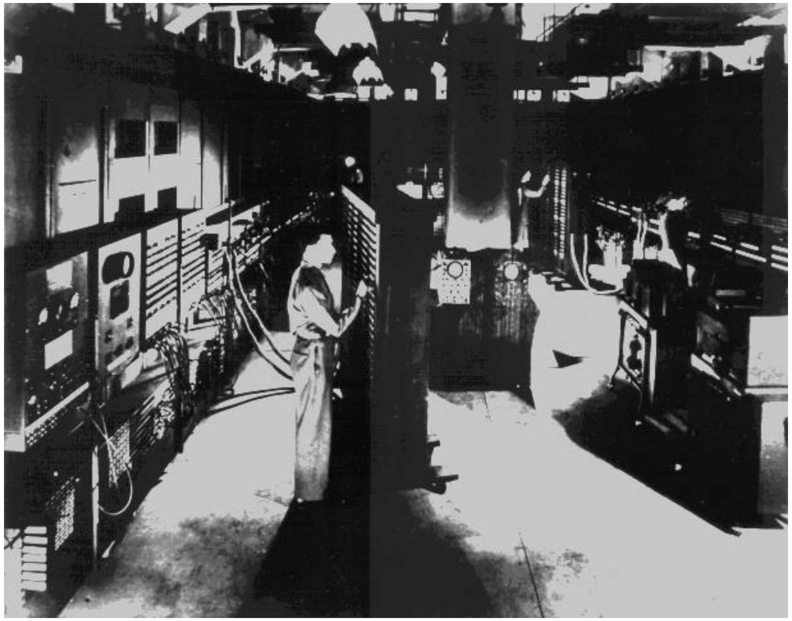
Early computers were relatively slow, performed maybe 1000 operations per second, and did not store much information

To make computers faster and smaller we needed to switch to binary arithmetic and storage

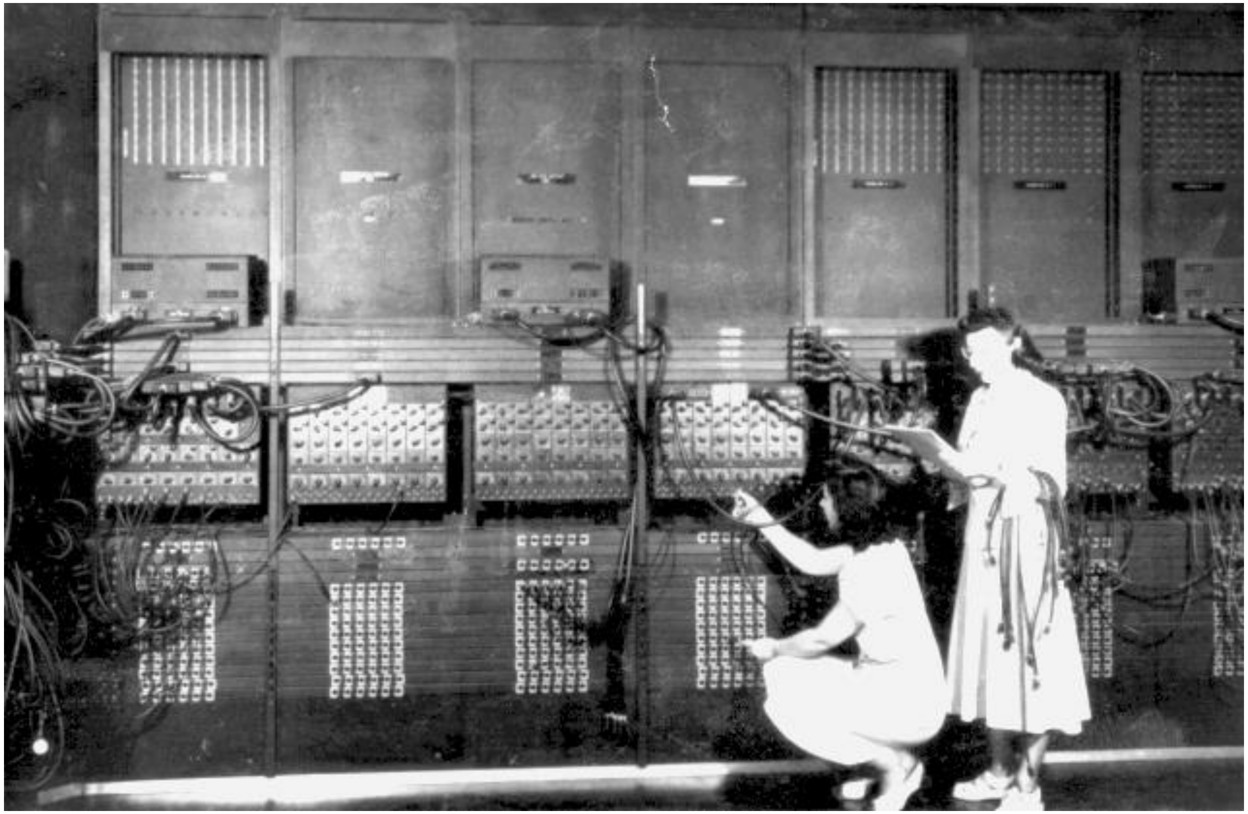
The circuits used for decimal arithmetic are slower than the equivalent circuits for binary arithmetic, and they are larger.

ENIAC – 1946 – First General use Computer

It was Turing-complete, digital, and capable of being reprogrammed to solve "a large class of numerical problems".



ENIAC - 1946



Modern Computers

Modern computers can perform billions of operations per second

Most computers have special processors for media processing, particularly sound and graphics

This high speed processing is what makes digital media possible

Now lets turn to how we represent different types of media in digital form

Text Representation

DIGITAL MEDIA

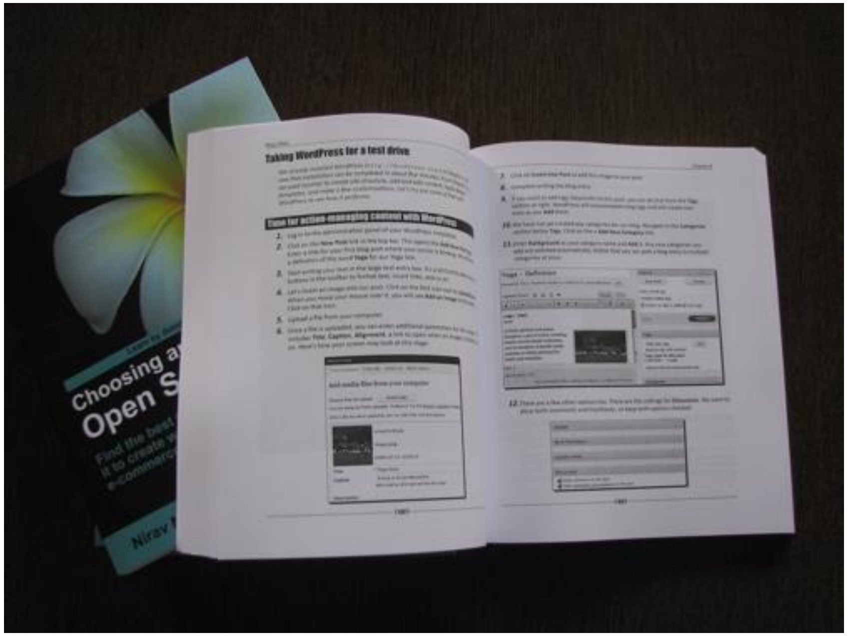
Text Representation

Basic text representation is easy, we just use 1 or 2 bytes per character depending upon the language

This is an exact representation of the text, as long as we are not concerned about any of the formatting information

What about Formatting?

In a book the text is divided into paragraphs and chapters, and we may want to include tables and figures



Formatting Text

Formatting text is a complicated problem, particularly if we want it to print nicely

On the printing side Adobe invented two formats for printed text, postscript and PDF

Postscript is really a programming language for printing, so a printed document is converted into a program that is downloaded to the printer

The printer executes this program to print the text document

Postscript Program and Output

```
% Start the prologue section.
% First make some font definitions.

% define "fnr" to be 10 pt Helvetica.
/fnr /Helvetica findfont 10 scalefont def

% define "fni" to be 10 pt Helvetica-Oblique.
/fni /Helvetica-Oblique findfont 10 scalefont def

% define "fnb" to be 10 pt Helvetica-Bold.
/fnb /Helvetica-Bold findfont 10 scalefont def

% Define some procedures to move to a given position,
% switch fonts, and show the given character string.

/shwr {moveto fnr setfont show} def
/shwi {moveto fni setfont show} def
/shwb {moveto fnb setfont show} def

% Start the script section.

(This is in Helvetica.) 45 292 shwr
(This is in Helvetica-Oblique.) 45 280 shwi
(This is in Helvetica-Bold.) 45 268 shwb
(And more in Helvetica.) 45 256 shwr
...
```

This is in Helvetica.
This is in Helvetica-Oblique.
This is in Helvetica-Bold.
And more in Helvetica.

Postscript Pros and Cons

Postscript was the main representation used by laser printers for several decades

Pros:

- we can represent almost anything that can be printed
- the postscript program has complete control over the printer

Cons:

- the program did not execute the same way on all printers
- a file that prints correctly on one printer might crash another printer

In reality this was not a printer independent format

PDF: Portable Document Format

PDF solves this problem, prints the same way on all printers

It is a file format used to present documents in a manner independent of application software, hardware, and operating systems.

A PDF file is harder to tamper with than a postscript file, so it is also a good mechanism for exchanging documents

This solves the printing problem, but what about creating and editing documents?

Editing Documents

Historically each text processing program used its own format for storing documents

This was good until you needed to exchange documents with someone else or you bought a new text processing program

Even single products, like Microsoft Word have used multiple formats over the years

File Formats

This created a need for programs that converted from one representation to another, and as the number of representations grew this became impossible

There is now an attempt to produce one (or maybe two) representation that is used by all text processing programs

This representation is based on XML

XML

XML is based on a family of representations that started with SGML (Standard Generalized Markup Language) and includes HTML

SGML was developed in the 1980s for representing formatting information in text documents

SGML is a textual representation, so SGML files are human readable, but the formatting is not particularly nice

Example XML

```xml
<?xml version="1.0" encoding="UTF-8"?>
<note>
  <to> Chris</to>
  <from>Patricia</from>
  <heading>Reminder</heading>
  <body>Don't forget me this weekend!</body>
</note>
```

XML Popularity

A number of software tools have been developed around XML to make it easier to write programs that use it

As a result XML has become a popular format for textual information

Sampling

DIGITAL TECHNOLOGIES

Sampling

Text is the only media type that we can represent exactly in digital form

For all the other media types we just use an approximation, not an exact copy

How do we do this? How do we know if the approximation is good enough?

To solve this problem we use a technique called sampling, which is basically measuring the media at well chosen points

Sampling

To see how sampling works we will return to sound

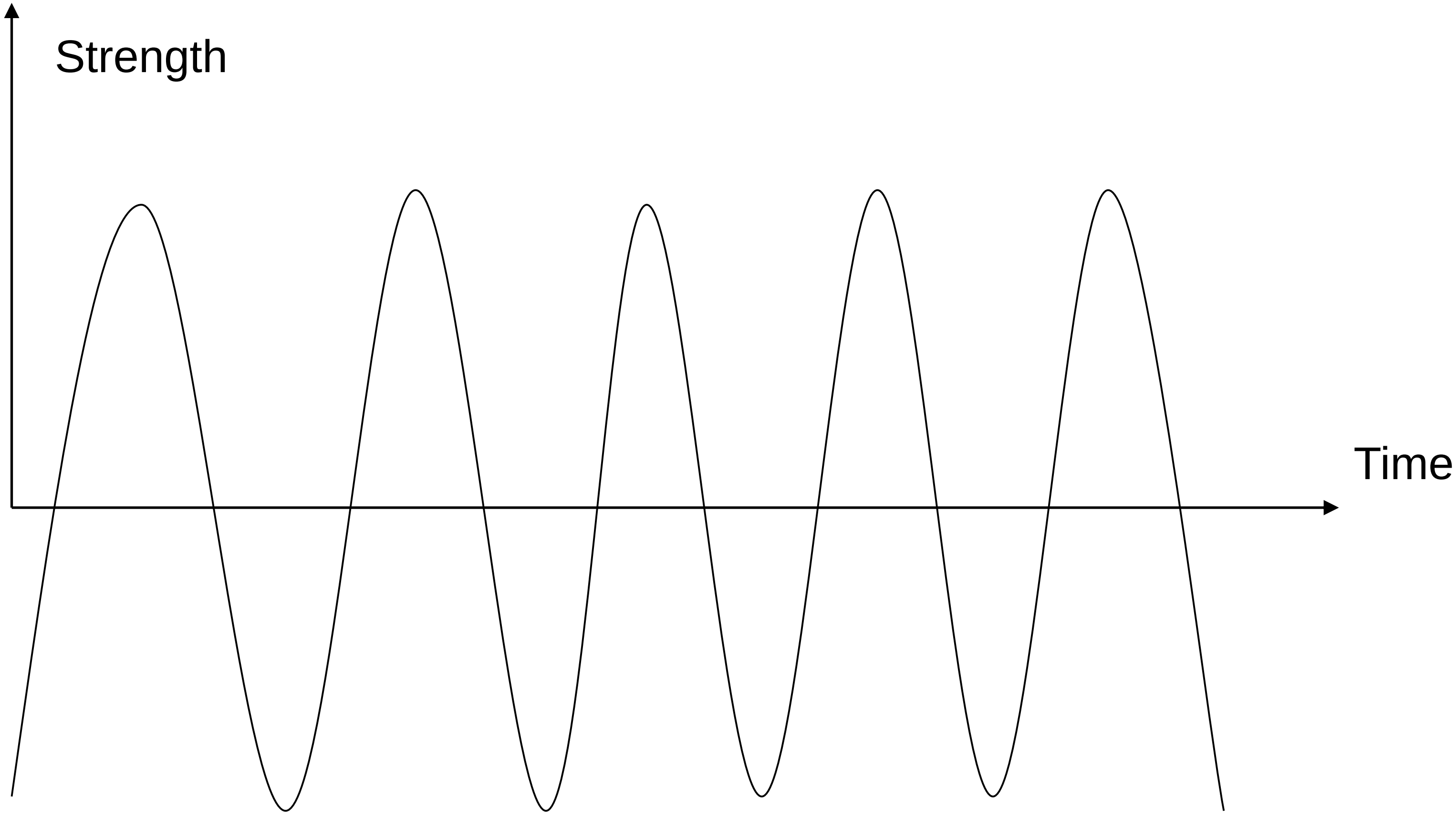
- simpler than the other media we sample
- the basic ideas are the same for other media

Start with a pure sound

A graph of this sound is shown on the next slide, the graph shows the strength of the sound versus time

The strength could be the air pressure or the signal produced by a microphone

Signal



Turning the Signal into Numbers

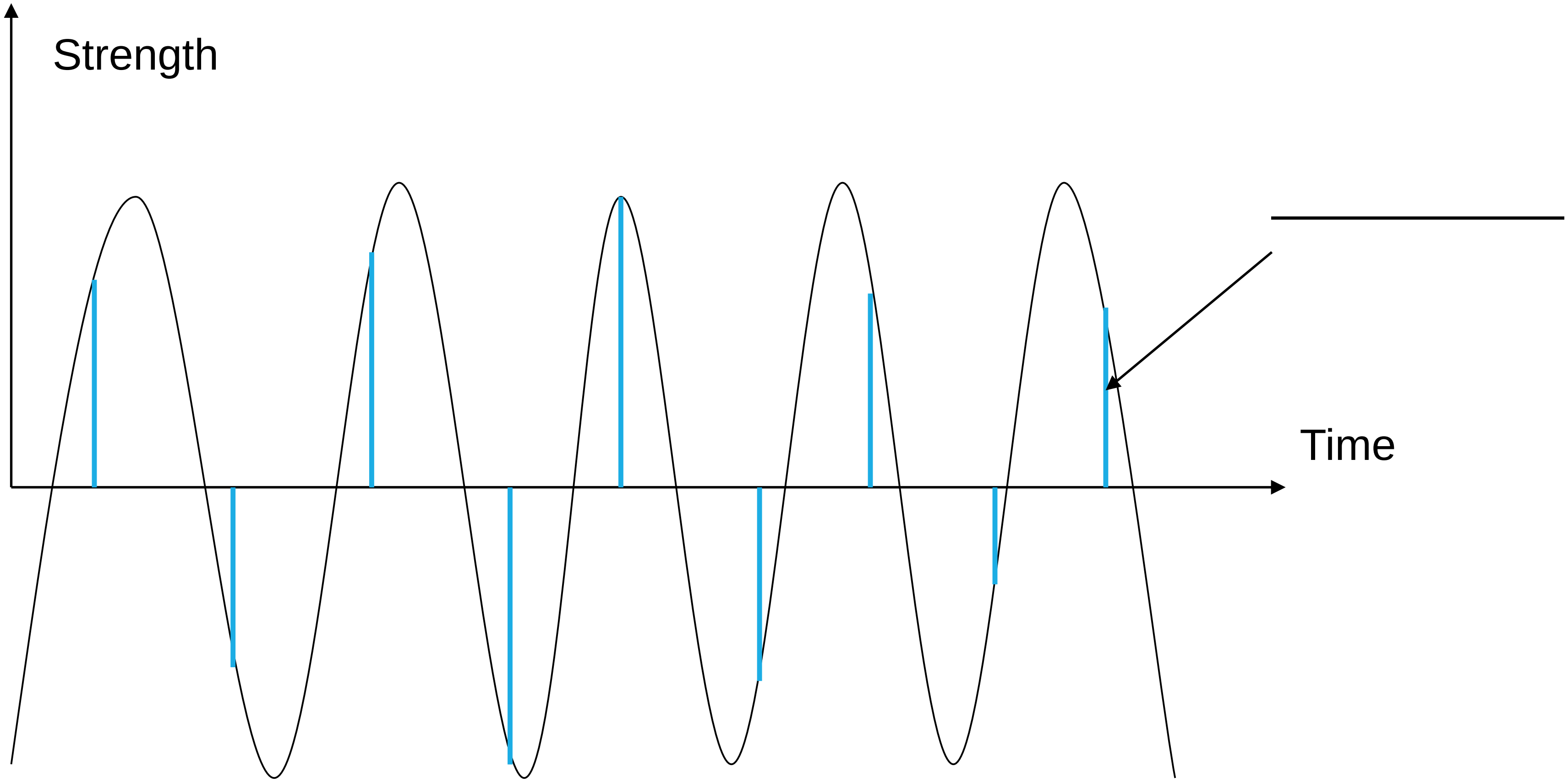
Now we have the problem of converting this signal into bytes

We do this by measuring the sound at fixed points in time = sampling

We then convert these measurements into bytes

The next slide shows how this might be done, in this slide the blue lines are the samples

Sampling



Samples into Sound

Instead of having the complete signal or vibration pattern we just have a sequence of numbers (samples)

- the signal at fixed points in time

We can convert this sequence of numbers into a voltage level and then send these voltages to a speaker

If we do the sampling correctly and add some of electronics the sound coming out of the speaker will sound like the original sound

But wait…

Our digital sample contains enough information to completely reconstruct the original signal

But, we did not store the entire signal, how could this be possible?

The answer lies in some mathematics..

The electrical engineers study this stuff, so we do not need to worry about it

Sampling Theorem

This leaves us with two questions:

- How frequently do we sample?
- How much storage do we use for each sample?

Thanks to Shannon and his Sampling Theorem we know how frequently we need to sample

Shannon worked for Bell Labs, and they were interested in reducing the cost of long distance phone calls, they planned to do this by converting the phone system to digital

Sampling Theorem

The basic ideas behind the Sampling Theorem were known before Shannon

He was the one that showed why it worked, he proved the theorem

The Sampling theorem tell us to do the following:

- Determine the highest frequency in the signal
- Sample the signal at twice this frequency

If we do this we can reproduce the signal

Sampling Theorem Example

The mathematics is much more complex, but we can safely ignore it

Example: consider our example signal from before

We measure this signal and determine that its highest frequency 10,000 Hz

The sampling theorem tells us that we must sample this signal at least 20,000 times per second

Sampling: CDs

It is all pretty easy, find the highest frequency and multiply by 2

We can reverse engineer this for CDs

The sampling rate for CDs is 44,100 times per second

To get the highest frequency we can reproduce with a CD we divide by 2

This gives around 22KHz as the theoretical highest frequency

CDs < (Idealized) Vinyl

This is our first practical result

We can hear up to 24 KHz, but a CD only gives us around 22 KHz, which is less than an (idealized) vinyl record..

Back to CDs

Thus, a CD can easily miss some of the frequencies that are important for interpreting sounds

So how high do we really need to go?

Once we have done the sampling we cannot recover information we have lost

A CD is stuck at 22KHz, we cannot use this as a source of higher quality sound, it just is not there

Modern Sampling

To play it safe most digital sound recording is done with a minimal sampling rate of 96 KHz and sometimes as high as 192 KHz

This can safely be sampled down to produce CDs and other media types

Now we have the problem of determining the number of bits or bytes required to store each sample

Storing the Samples

Unfortunately there are no mathematical theories to help us here

Its clear that a single byte is too small, it only gives 256 possible values, but this is good enough for speech

If we go to 2 bytes, or 16 bits we end up with 65536 possible values

The quietest sound would have value 0, and the loudest sound would have value 65535

This the scheme that CDs use, so it works for music as long as there are no major changes in volume

Bytes per Sample

For high quality sound recording we typically use 3 or 4 bytes per sample

This does not give us the full range of volumes that we can hear, but it gets pretty close

Note: this has largely been determined by trial and error and as we push for higher quality we go for more bytes per sample

DVD-A

The following slide shows the sampling rates and sample sizes that can be used with DVD-Audio

A DVD-Audio only has sound information, it has no video

The sound on a regular DVD will not be at the quality levels shown here, but it will be better than a CD

Sampling

TABLE 11.2 The DVD-Audio specification supports a variety of coding methods, each with many possible recording parameters. Some examples are shown here.

Audio coding	Sample rate (kHz)	Word length	Number of channels
LPCM	192	16, 20, 24	2
	176.4	16, 20, 24	2
	96	16, 20, 24	1 to 6
	88.2	16, 20, 24	1 to 6
	48	16, 20, 24	1 to 6
	44.1	16, 20, 24	1 to 6
MLP	192/176.4	16, 20, 24	2
MLP	96, 88.2, 48, 44.1	16, 20, 24	1 to 6
Dolby Digital	48	16, 20, 24	1 to 6
DTS	48/96	16, 20, 24	1 to 6

Samples are Just Numbers!

By using sampling we can convert sound into a sequence of bytes

As long as we are careful the sampled sound appears to be the same as the original sound to us

But, a sequence of bytes is just the same as any file on a computer, so we can treat sound in exactly the same way as any other information on the computer

Copying Digital Information

If we copy a sound file we get an exact copy of the file, it is the same as the original

With analog recording each copy added noise, so the copies did not sound as good as the original, this is not the case with digital sound

Second we can transfer sound over a network in the same way as any other file

No matter how far we send it, the destination gets the exact same file

Digital Eases Distribution

Once we get the media into digital form distribution is much easier

We can make as many copies as we like and send it anywhere without any impact on quality

This was not the case with analog media, copies and transmission always decreased the quality of the media