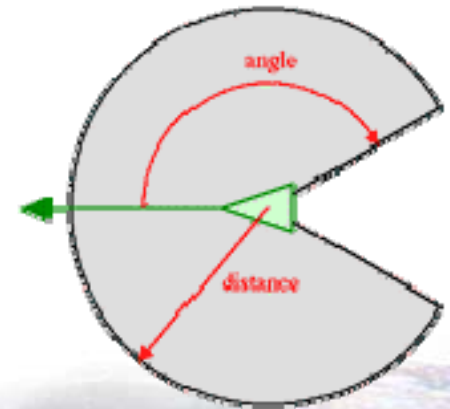
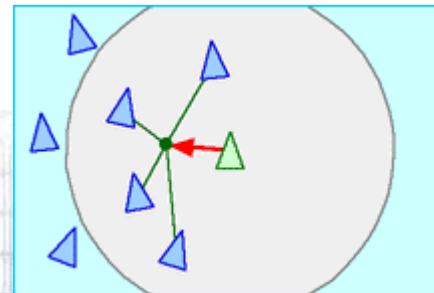
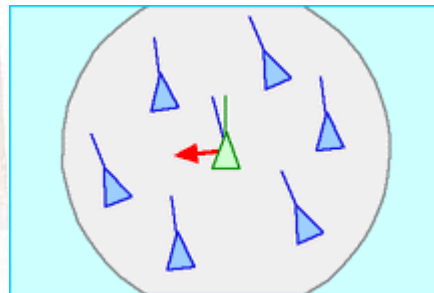
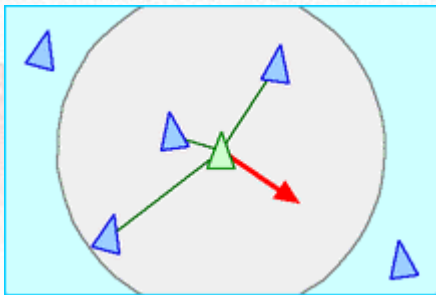


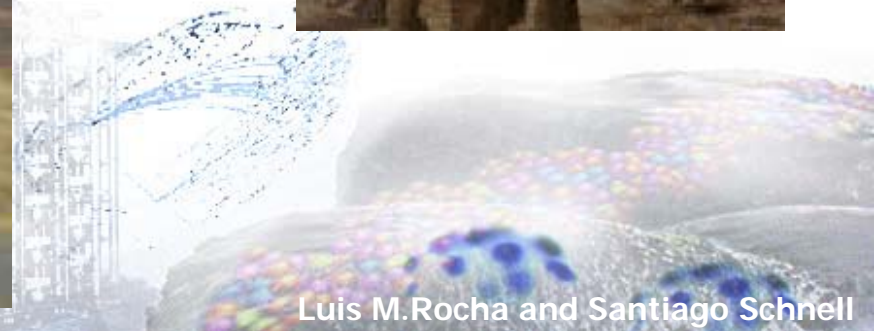
Flocking Behavior

- Boids by Craig Reynolds (1986)
 - 3 Steering behaviors
 - **Separation**: steer to avoid crowding local flockmates
 - Maintain minimum distance to others
 - **Alignment**: steer towards the average heading of local flockmates
 - Adjust speed according to others in vicinity
 - **Cohesion**: steer to move toward the average position of local flockmates
 - Each boid sees only flockmates within a certain small neighborhood around itself.
 - <http://www.red3d.com/cwr/boids/>



Boids Used in Movies

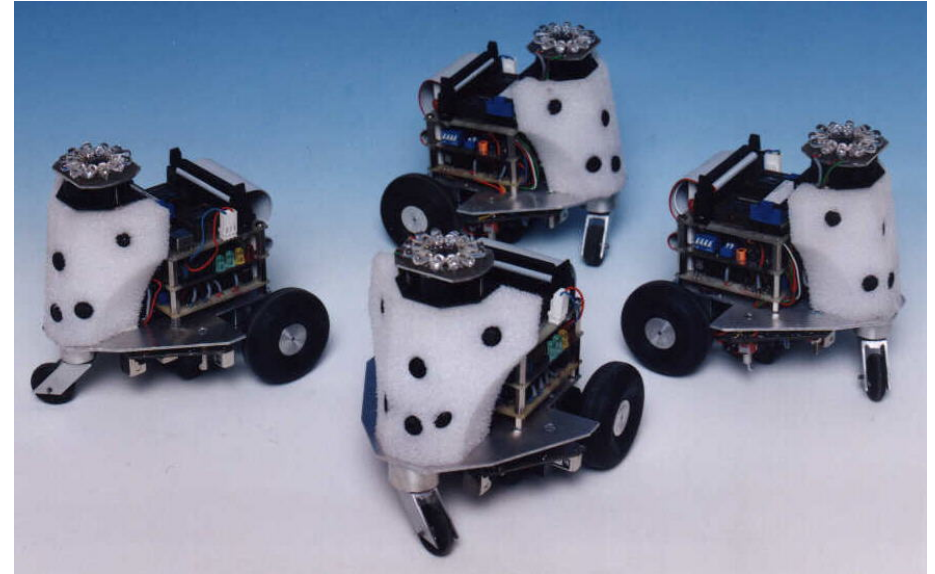
- **Batman Returns**
 - to simulate bats and penguins
- **Cliffhanger**
 - Simulation of bats
- **Jurassic Park**
 - Simulation of gallamunus herd
- **The Lion King**
 - Scene of wildbeast stampede
- **Jumanji**
 - Stampede of zoo animals
- **Star Trek Voyager "Elogium"**
 - Simulation a swarm of space creatures



flocking robots



Intelligent Autonomous
Systems Laboratory.
University of the West of
England.



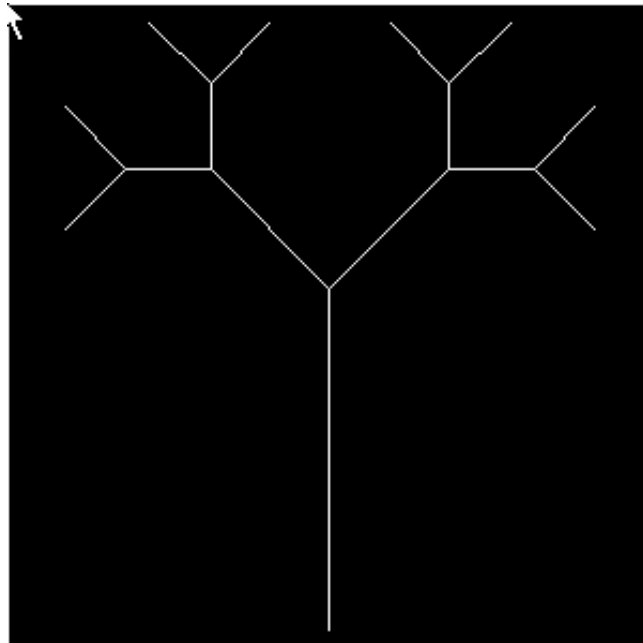
Cybernetic Intelligence Research Group,
University of Reading, England



Luis M.Rocha and Santiago Schnell

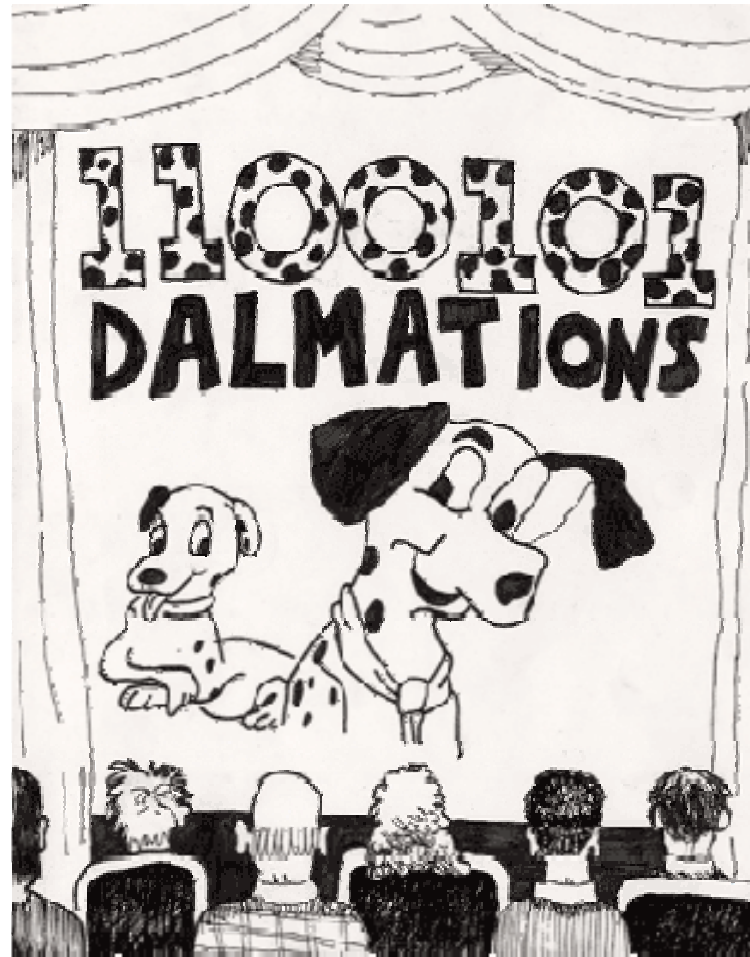
Possible Questions

1. Describe the Hertz Modelling Process
2. What are Boids and how do they work?
3. Propose an L-System Rule to draw the following artificial plant



Introduction to Informatics

Lecture 9: Data Representation



Film Night at the Einary Society

Luis M.Rocha and Santiago Schnell

Readings until now

- Lecture notes
 - Posted online @ <http://informatics.indiana.edu/rocha/i101>
 - *The Nature of Information*
 - *Technology*
 - *Modeling the World*
 - @ *infoport*
 - From course package
 - Von Baeyer, H.C. [2004]. *Information: The New Language of Science*. Harvard University Press.
 - Chapters 1, 4 (pages 1-12)
 - From Andy Clark's book "*Natural-Born Cyborgs*"
 - Chapters 2 and 6 (pages 19 - 67)
 - From Irv Englander's book "*The Architecture of Computer Hardware and Systems Software*"
 - Chapter 3: Data Formats (pp. 70-86)

Assignment Situation

- Labs
 - Past
 - Lab 1: Blogs
 - Closed (Friday, January 19): Grades Posted
 - Lab 2: Basic HTML
 - Closed (Wednesday, January 31): Grades Posted
 - Lab 3: Advanced HTML: Cascading Style Sheets
 - Closed (Due Friday, February 2)
 - Lab 4: More HTML and CSS
 - Due Friday, February 9
 - Next: Lab 5
 - Introduction to Operating Systems: Unix
 - Due Friday, February 16
 - Open Steel Account (instructions online)
 - Intro to Operating Systems
- Assignments
 - Individual
 - First installment
 - Due: February 9
 - Group Project
 - First installment
 - Presented: February 20, Due: March 9th
- Midterm Exam
 - March 1st (Thursday)



Individual assignment

- Individual Project

- 1st installment

- Presented: February 1st

- Due: February 9th

- 2nd Installment

- Presented: February 13th

- Due: March: 2nd

- 3rd Installment

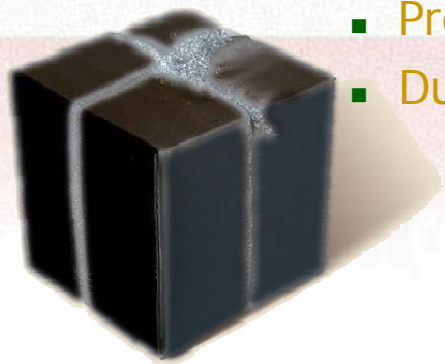
- Presented: March 8th

- Due: March 30th

- 4th Installment

- Presented: April 5th

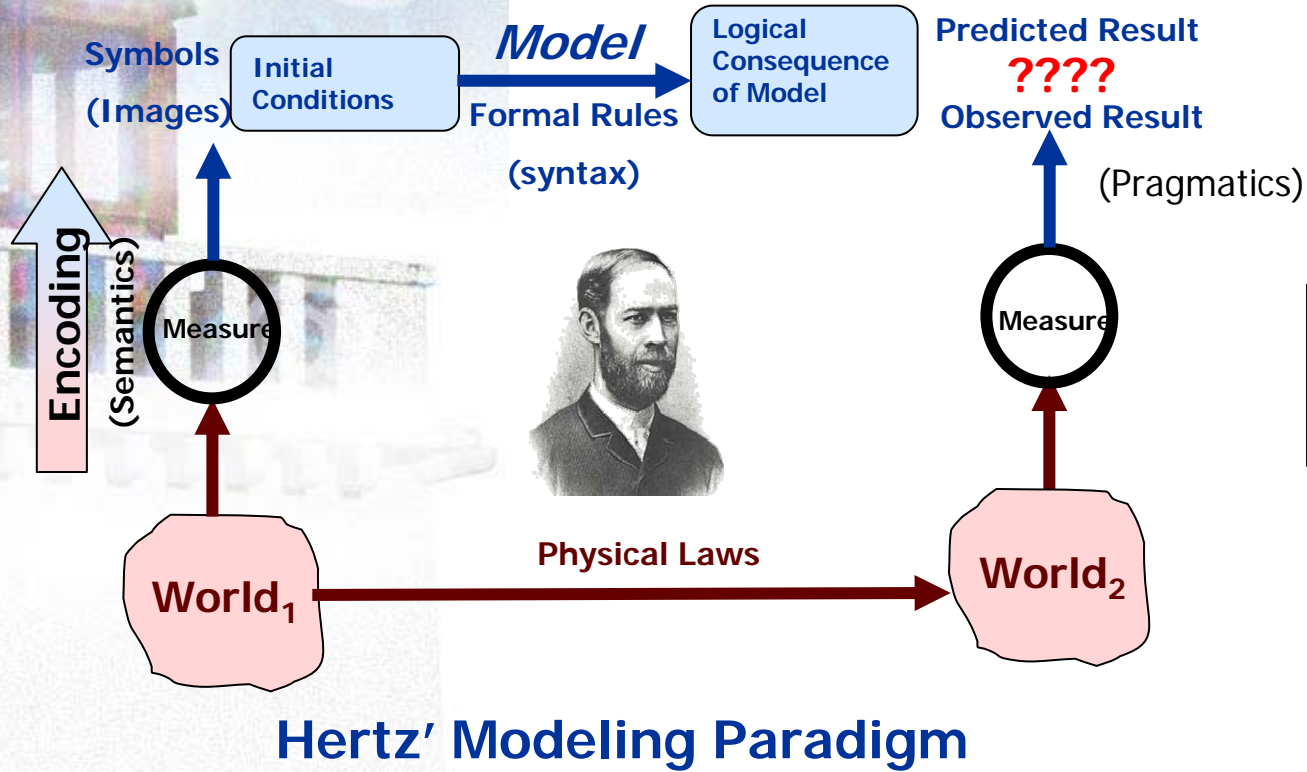
- Due: April 20th



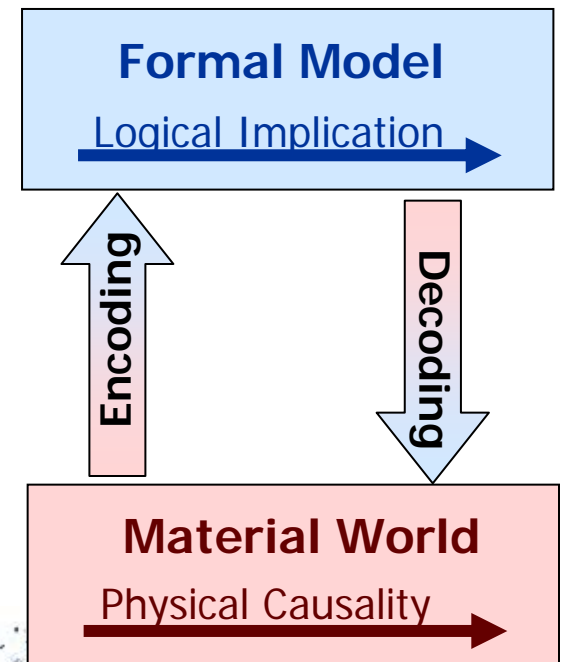
The Black Box



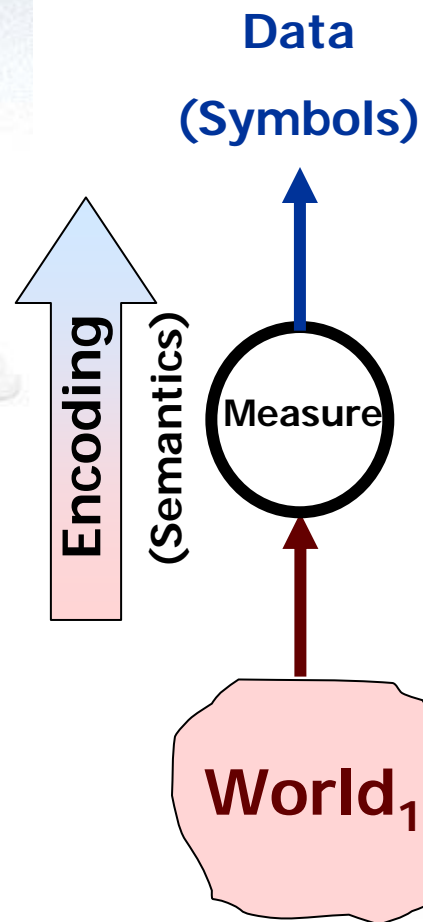
The Modeling Relation



Rosen's Modeling Relation



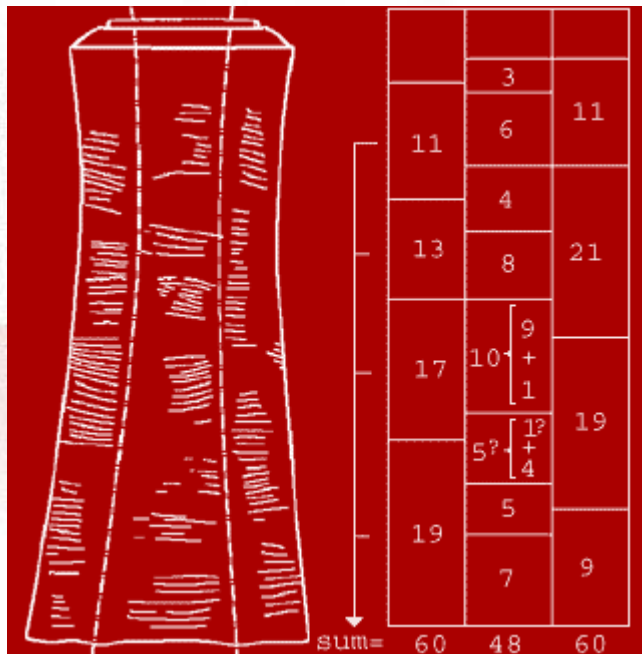
Encoding in the Modeling Relation



- How to encode data?
 - What is data?
 - Information without context and knowledge
 - Part of Syntax
 - Keeping Numbers
 - The most fundamental need for modeling and information

Encoding Numbers: Counting

- Tallying is the earliest form of modeling
 - Fingers (digits), stones (Lt "calculus"= Pebble), bones
 - **Lebombo bone**
 - Oldest counting tool is a piece of baboon fibula with 29 notches from 35,000 BC, discovered in the mountains between South Africa and Swaziland
 - Probably representing the number of days in a Moon Cycle (A Model!)
 - Czechoslovakian wolf's bone
 - with 55 notches in groups of 5, from 30,000 BC.



The *Ishango Bone*

- Oldest Mathematical Artefact?
 - 10,000 BC, border of Zaire and Uganda
 - Used as a counting tool?
 - 9,11,13,17,19, 21: odd numbers
 - 11, 13, 17, 19: prime numbers
 - 60 and 48 are multiples of 12

http://www.simonsingh.com/The_Ishango_Bone.html

Base for counting

- The use of numbers requires a base value

- The simplest is "one"

- 1: one item
- 2: two items
- Etc.



- A base defines how we consistently group items in counting

- An order of magnitude
- Roman and Egyptian numerals represent each order of magnitude by a different symbol

- I, II, III, IV, V, VI, VII, VIII, IX, X, ..., L, ..., C ..., D, ..., M, (7)



Let's go back to Bases



- Egyptian and Roman

- Each order of magnitude requires a new symbol
 - No "zero"
 - Omission of relevant group: MXX = 1020, MMV = 2005

- Hindu/Arabic System (*positional*)

- 6000 to 3000 BC
- Order of magnitude represented by location
 - With the same symbols!
 - Can represent huge numbers!
- Each position/order of magnitude denotes n times the last order of magnitude

- n is the *base!* (or *radix*)

- 10 is **10** times 1
- 100 is **10** times 10
- 1000 is **10** times 100, etc.

Hindu-Arabic (still used)	9	8	7	6	5	4	3	2	1	0
Arabic	9	8	7	6	5	4	3	2	1	0

- Arabic numerals disseminate in the west via the Iberian Kingdoms

- Castilian kings sent their children to be educated with Muslim kingdoms
 - al-Andalus
- Pope Sylvester II (Gerbert of Aurillac, 955-1003 AD)
 - In a monastery close to Barcelona (Kingdom of Aragón) had extensive contact with Muslims. Introduced the abacus, etc,

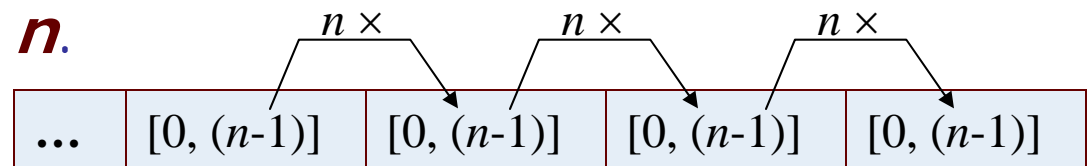
Positional Bases for digital counting

- *Digital* (from Latin word for finger *digitus*)
 - Used to convey the notion of discrete objects/values
 - Things we can count

- **Base n**

- Each position to the left is equal to n times the position to the right
- Each position to the right is equal to the position to the left divided by n .

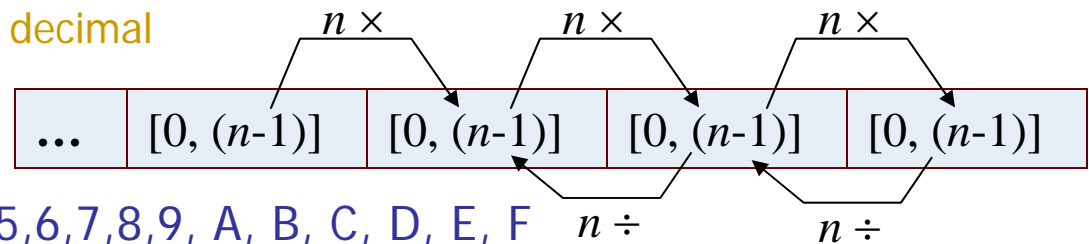
- **Decimal: Base 10**



- 10 symbols (digits): 0,1,2,3,4,5,6,7,8,9
 - Most frequent
 -[thousands]-[hundreds]-[tens]-[units]

Other digital Bases

- Base n
 - Each position to the left is equal to n times the position to the right
 - Each position to the right is equal to the position to the left divided by n .
- Octal: Base 8
 - 8 symbols: 0,1,2,3,4,5,6,7
 - $4096 - 512 - 64 - 8 - 1$
 - 402 in octal = 258 in decimal
 - The *Yuki* used base 8
- Hexadecimal: Base 16
 - 16 symbols: 0,1,2,3,4,5,6,7,8,9, A, B, C, D, E, F
 - $65536 - 4096 - 256 - 16 - 1$
 - 402 in octal = 258 in decimal = 102 in Hexadecimal
 - 7473 in octal = 3899 in decimal = F3B in Hexadecimal
- Vigesimal: Base 20
 - Mayan system: <http://www.saxakali.com/historymam2.htm>
- Binary: Base 2
 - 2 symbols: 0, 1
 - $256 - 128 - 64 - 32 - 16 - 8 - 4 - 2 - 1$
 - 100000010 in binary = 382 in octal = 258 in decimal = 102 in Hexadecimal



Background on Powers

An **exponent** is shorthand for **multiplying** that number of identical factors (the **base**)

exponent

$$\begin{array}{c} \boxed{a^b} \\ \text{base} \end{array}$$

$$a^b = \overbrace{a \times a \times \cdots \times a}^b$$

$$2^5 = 2 \times 2 \times 2 \times 2 \times 2$$

$$a^b = \overbrace{a \times a}^{b=c} \times \overbrace{\cdots \times a}^d = a^c \times a^d = a^{c+d}$$

Background on Powers

exponent

$$a^b$$

base

$$a^b = \underbrace{a \times a \times \cdots \times a}_b$$

$$a^c \times a^d = a^{c+d}$$

$$\frac{a^b}{a^c} = \frac{\underbrace{a \times a \cdots a}_b}{\underbrace{a \times a \cdots a}_c} = a^{b-c}$$

$$\frac{1}{a^c} = \frac{a^0}{a^c} = a^{0-c} = a^{-c}$$

$$a^0 = 1$$

$$a^0 = a^{b-b} = \frac{a^b}{a^b} = 1$$

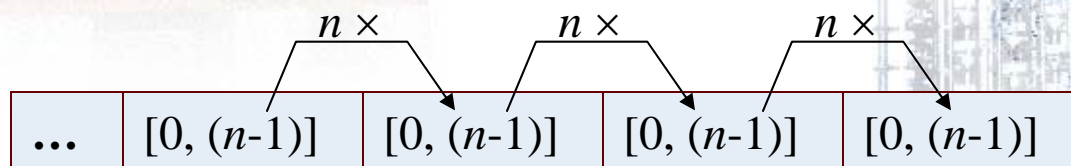
Counting with the Decimal System

- Positional number system

- the value of each digit is determined by its position
 - 683 is different from 836
 - The lowest place value is the rightmost position, and each successive position to the left has a higher place value

- Base 10

- The value of each position corresponds to powers of 10
 - $\dots d_4 d_3 d_2 d_1 d_0 = \dots + d_4 \times 10^4 + d_3 \times 10^3 + d_2 \times 10^2 + d_1 \times 10^1 + d_0 \times 10^0$
 - Each digit to the left is 10 times the previous digit.
 - $483 = 4 \times 10^2 + 8 \times 10^1 + 3 \times 10^0$
- To multiply a number by 10 you can simply shift it to the left by one digit, and fill in the rightmost digit with a 0
 - $483 \times 10 = 4830$
- To divide a number by 10, simply shift the number to the right by one digit (moving the decimal place one to the left).
 - $483 \div 10 = 48.3$
- With n digits, 10^n unique numbers can be represented
 - If $n=3$, 1000 ($=10^3$) numbers can be represented 0-999.



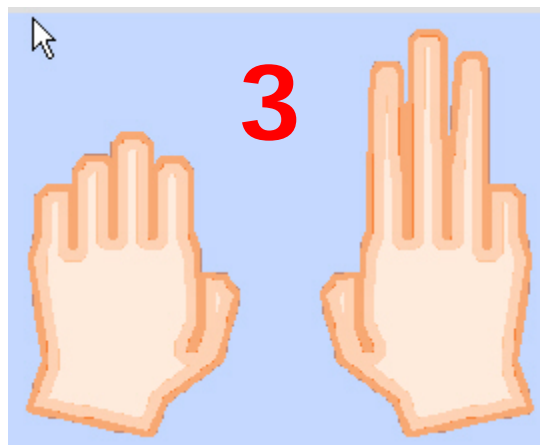
Let's Count decimal with fingers

- **Decimal Numeral System**

- 10 symbols (digits): 0,1,2,3,4,5,6,7,8,9

- **Base 10**

- Each position to the left is equal to 10 times the position to the right
- Each position to the right is equal to the position to the left divided by 10.



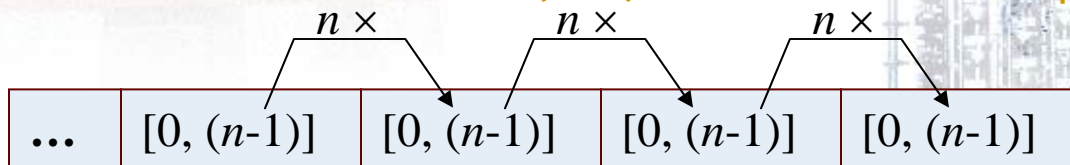
Counting with the Binary System

- Positional number system

- the value of each digit is determined by its position
 - 101 is different from 110
 - The lowest place value is the rightmost position, and each successive position to the left has a higher place value

- Base 2

- The value of each position corresponds to powers of 2
 - $\dots d_4 d_3 d_2 d_1 d_0 = \dots + d_4 \times 2^4 + d_3 \times 2^3 + d_2 \times 2^2 + d_1 \times 2^1 + d_0 \times 2^0$
 - Each digit to the left is 2 times the previous digit.
 - $111100011 (483) = 1 \times 2^8 + 1 \times 2^7 + 1 \times 2^6 + 1 \times 2^5 + 0 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$
- To multiply a number by 2 you can simply shift it to the left by one digit, and fill in the rightmost digit with a 0
 - $101 \times 2 = 1010 (5 \times 2 = 10)$
- To divide a number by 2, simply shift the number to the right by one digit (moving the decimal place one to the left).
 - $101 \div 2 = 10.1 (5 \div 2 = 2.5)$
- With n digits, 2^n unique numbers can be represented
 - If $n=8$, 256 ($=2^8$) numbers can be represented 0-11111111.



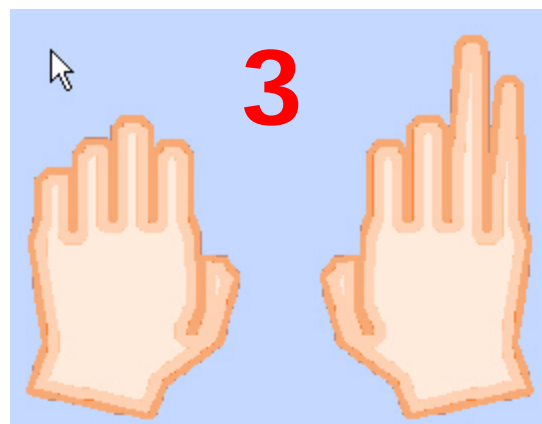
Let's Count binary with fingers

- Binary Numeral System

- 2 symbols: 0,1

- Base 2

- Each position to the left is equal to 2 times the position to the right
- Each position to the right is equal to the position to the left divided by 2.



**Can count up to
1023!!!**

<http://www.intuitor.com/counting/HandCounter.html>

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Converting Binary to Decimal

- $2^8 = 256$

- $2^7 = 128$

- $2^6 = 64$

- $2^5 = 32$

- $2^4 = 16$

- $2^3 = 8$

- $2^2 = 4$

- $2^1 = 2$

- $2^0 = 1$

2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
-------	-------	-------	-------	-------	-------	-------	-------	-------

0	1	1	0	0	1	0	0	1
---	---	---	---	---	---	---	---	---

128	+	64
-----	---	----

+	8
---	---

+	1
---	---

201

$$\dots d_4 d_3 d_2 d_1 d_0 =$$

$$\dots + d_4 \times 2^4 + d_3 \times 2^3 + d_2 \times 2^2 + d_1 \times 2^1 + d_0 \times 2^0$$

Comparing Binary with Decimal

- Binary:Decimal
 - 0000:00
 - 0001:01
 - 0010:02
 - 0011:03
 - 0100:04
 - 0101:05
 - 0110:06
 - 0111:07
- Binary:Decimal
 - 1000:08
 - 1001:09
 - 1010:10
 - 1011:11
 - 1100:12
 - 1101:13
 - 1110:14
 - 1111:15





Next Class!

- Topics
 - Encoding Text
 - Encoding Multimedia
- Readings for Next week
 - Lecture notes Posted online @ <http://informatics.indiana.edu/rocha/i101>
 - *Modeling the World*
 - @ *infoport*
 - Read Binary encoding resources at Infoport!!
 - From course package
 - From Irv Englander's book "*The Architecture of Computer Hardware and Systems Software*"
 - Chapter 3: Data Formats (pp. 70-86)
- Lab 5
 - Introduction to Operating Systems: Unix