CS 2461
Lab- Week 3

Announcements….

- HW 2 on BB due Monday 10 am
  - Announcements won't always be made
  - Check BB for HWs

- Get ready…
  - This class is going to gear up VERY soon
  - Stay on top of work, utilize office hours, don't wait until last minute!!!

Today….

- Example/exercise: Boolean expression for a problem

- Exercises with Adder/Decoder/Multiplexer (Set2.cdl file)

Truth Tables to Boolean Function/Circuits (a procedure)…

- A truth table can be mapped to a Boolean function
  - In **Disjunctive Normal Form (DNF)** – an OR of AND terms
    - Recall from Discrete 1 (CS1311)
- Each row in the truth table corresponds to a conjunction (AND) of literals (i.e., Boolean variables) and is called *minterm*
  - Literal is Boolean variable A or its complement A'
  - Conjunction is an AND of the minterms
- To derive the Boolean function F:
  - Examine each row where the output = 1
    - Include this conjunctive term as an AND of the literals
  - F = OR of the included terms (minterms)
    - Also called sum of products (OR of minterms)

Constructing truth table to solve a problem

- Read problem description and identify the (input) variables and the outputs
- How many variables in the problem ?
- Label the input and output variables, eg. A,B,C etc.
- For each combination of input variables, determine the value of the output variable(s)

- From truth table, construct Boolean expression

Transporting a wolf, a goat, cabbage across the river (!!)

- There is an old puzzle in which a Farmer must transport a Wolf, a Goat, and a Cabbage across a river from the West bank of the river to the East bank of the river. However, the farmer can only transport one of Wolf, Goat or Cabbage across the river at a time, and if left together on the same river bank and unattended (i.e., the farmer is not on the same river bank with them), the goat will eat the cabbage and the wolf will eat the goat.
- At any point in time, each of these four (Farmer, Goat, Wolf, Cabbage) are on the East bank or the West bank (there is no other place they can be!)

- Derive a truth table for a function D (danger!) which outputs 1 if the farmer is in danger of losing the goat or the cabbage (and outputs D=0 if there is no danger of this happening).
  - You may assume that a trip across the river can be made instantaneously, so that if an item (or farmer) is not on one side of the river it must be on the other side.
- From truth table, determine the Boolean function for D

Transporting a wolf, a goat, cabbage across the river – getting started

1. First, what are ”variables” ?
   - Label them
2. Next, when are the values of these variables a 0 or a 1
   - Associate the values (encoding!) with a position on the river bank
3. For each combination of the values of the input variables, determine if Danger =1 or Danger =0
   - Determine if Wolf eats Goat or Goat eats Cabbage
   - When does this happen ?

Transporting a wolf, a goat, cabbage across the river – getting started

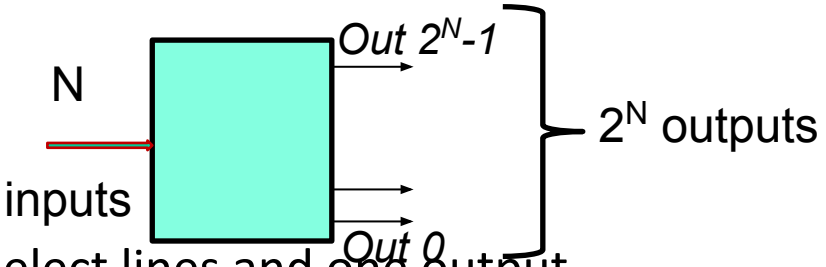
1. First, what are ”variables” ?
   - Label them Farmer F, Goat G, Wolf W, Cabbage C
2. Next, when are the values of these variables a 0 or a 1
   - Associate the values (encoding!) with a position on the river bank
   - 0 = west bank of the river, and 1= east bank of the river
   - Eg. Let F=0 indicates farmer on the west bank of the river and F=1 indicates farmer on the east bank. Use similar definitions for W, G, and C.
3. For each combination of the values of the input variables, determine if Danger =1 or Danger =0
   - Determine if Wolf eats Goat or Goat eats Cabbage
   - When does this happen ?

▪ Complete the truth table

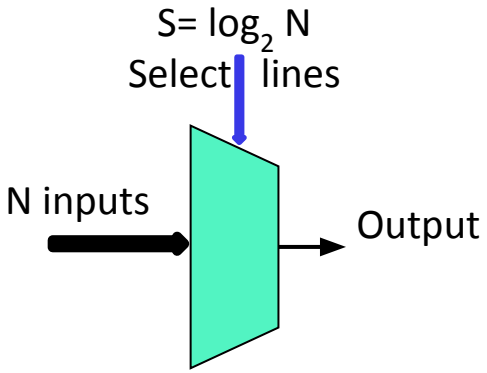
Decoders, Multiplexers, Adders

Decoders and Multiplexers

- N-2^N Decoder: has N inputs and 2^N Outputs
  - Exactly ONE of the outputs=1 depending on the N bits input
  - Schematic:



- N-1 Multiplexer: has N inputs, $\log_2$ N select lines and one output
  - selects one of the N inputs (to be sent) as the output – channel selector
    - It needs $\log_2$ N 'select lines' to determine which of the N inputs is selected
  - Schematic:



Examples/Exercises – Set2.cdl file from webpage

- Log in to a Windows machine
- Download CedarLogic-Circuits-Set2:Comb Devices file from webpage to your desktop and open in CedarLogic
- Page 3: Was a circuit for subtraction Y-X
  - X was complemented to get X' and Carry-in=1 to the adder
  - Adder computers Y + X' +1 but (X' +1) = -X (in 2's complement)
- Page 5: F1= (A'B') AND x1 AND y1 F2= (A'B) AND x2 AND y2 …..
  - Decoder sets exactly one output =1 which means exactly one of the AND gates has an input=1 from the decoder
  - If any one input to AND gate=0 then output=0
  - If any one input to AND gate=1 then output depends on AND of the other inputs
- Page 7: F= x'(BD) + x(AC)
  - Output of each MUX depends on select line x
  - If x=0 then output of top MUX = B and output of bottom MUX = D
  - If x=1 then output of top MUX=A and output of bottom MUX=C
  - These are sent to AND gate
    - So if x=0 then (B AND D) is the output