An nyung ha se yo

ECE 817

Emerging Computing Technologies

Some slides that are not my own, come from various sources. These sources will be listed at the end of each set of slides corresponding to one lecture.

Additional materials on my Web Page

ECE 817
Emerging Computing Technologies

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- **My room:** Yang Sang Dong, left room of 1325
- Everybody is welcome to come to my room to introduce yourself and ask questions.

ECE 817
Emerging Computing Technologies

Lecture 1

Introduction and Administrativia

- Introduction
- Grading
- What is this class about
- Example of a covering problem
- Shortest intro to EXOR logic
- First homework

Do not take notes

All slides will be on my webpage

All homework and project explanations will be on my webpage

I do not assume much background knowledge from you

Basic Boolean Logic

Basic graph theory

Basic linear algebra

Basic programming skills in Basic or C, C++

The good news is that I will review much of this background material

Also, there will be additional meetings just to review the material and solve problems.

Participation in those meetings is not mandatory, and you can get an A without participating.

However, participating will help you in homeworks and projects.

Mr. Young Doo Kim will help me as a TA for this class. Please communicate with him and he will relate your questions to me

All homeworks, projects and final exam will be graded by me only.

Goals of this class

- Do you know what technologies are believed to dominate in 30 years from now in computing and communication? **Here you will learn**.
  - *Some top specialists from NASA believe that quantum computing will be in mainstream in 2005*.
- Do you want to design circuits and algorithms for emerging computing technologies? This class will help. I will teach both **fundamentals** and **applications**.
- Teach about relations between concepts, circuits, data structures, algorithms and architectures.
- The algorithms and concepts presented in this class are ***very general***. They can be used in several future technologies.
- We will concentrate on ***basic concepts and algorithms*** and will illustrate applications. This is not physics or mathematics class.

Objective of Subject

- Both theory and practical applications.
- Do not be scared that the class is taught in English.
- If I speak too quickly, please tell me.
  - I will slow down.
  - **Really!! Do not be too nice!**
- There will be homeworks and exams. You have to solve problems systematically.
- I will give you some challenging research problems that nobody solved or even formulated.
  - You can work on them and we can publish them, **but it is not mandatory,** only for those who like a challenge.

Objective of Subject

- Students will learn ***about techniques of specifying*** fundamental computer and communication blocks on level of algorithms and circuits.
- These techniques can be used to **Computer, Digital Signal Processing (DSP), Communication and Image Processing architectures.** You can use your own examples.
- At the end, some recent research papers from top conferences and journals will be discussed to show the modern research areas and **hot topics**.
- Modern realization technologies will be presented, **FPGAs**
- **Unified approach to many problems.**
- **After completing the class students should be able to understand the fundamentals and role of emerging technologies**

Homeworks

- Homeworks will be to solve practical problems illustrating the algorithms and data structures.
- To allow early problem-solving experiences, early emphasis will be on reversible logic and cellular automata.
- One homework will be to create an **animated PowerPoint** presentation and present it in the class.

Grading System

- Homeworks = 35 %
- Midterm = 15 %
- Final Exam = 20 %
- Project = 30 %
  - Final examination (in class, you will have a lot of time) - Questions from all the course, but with emphasis on the second half of the course.
  - Midterm Examination (open book, in class)
  - Homeworks, including student presentations
  - Project:
    - » programming
    - » theoretical work
    - » literature study
    - » designs using methods from the class

Remember that the midterm exam is:

Open Book

Remember that I really want to help you to be successful in this class and obtain a good grade.

Do not be afraid to speak in English, it is better to speak with mistakes than to avoid communication

TEXTBOOK

- <u>Strongly Recommended</u>

  Michael A. Nielsen and Isaac L. Chuang

  Quantum Computation and Quantum Information

  - **This textbook is the most popular in USA and is used in top universities**
  - It has many examples and its language is quite easy.
  - Even if you do not understand my English, you can learn from this textbook to get a grade of A in this class. My examples and additional material that I will teach is just to help to illustrate the ideas better. They will be NOT required in homeworks and exams.
  - The material from the book will be on slides. All slides can be printed and used to learn the material.

- Background
  - Randy Katz, *Contemporary Logic Design*, Benjamin/Cummings, 1994. This book is already used in KAIST.

Other Information

- There is a WWW Home page for the class. I will keep updating it every day, also to reflect a feedback from you.
- All PowerPoint 4.0 slides you see here, plus a Postscript printable version with 6 slides per page will be available.
- Lectures will be available within 24 hours after the lecture is given (mainly because I will be completing the lectures on Sunday nights and Monday mornings prior to the lecture).
- All sorts of other info will be there as well.
- Class announcements will appear in the “class schedule” pages of this class at the KAIST WWW page of Marek Perkowski.
- Much additional material is on my US webpage, but using it is not mandatory.

Other Information

- Use **Internet Explorer** or **Netscape** to view these pages.
- Send emails with questions.
- If you are shy to ask in class or want to be anonymous, please leave me a question on a paper sheet before class on the desk.
- I will post news for class students of this group. I presume that it is read within 2 or 3 working days. **YOU ARE RESPONSIBLE FOR READING THE NEWS IN CLASS SCHEDULE LINK!**

Any Other Administrative Details?

- ! Now is the time to ask

Additional Monday meeting

Friday meetings

Karnaugh Map

Natural number of the cell

Gray Code

WX \ YZ	00	01	11	10
00	0 **1**	1 **1**	3 **0**	2 **1**
01	4 **0**	5 **1**	7 **1**	6 **1**
11	12 **0**	13 **0**	15 **0**	14 **1**
10	8 **1**	9 **1**	11 **0**	10 **1**

Gray code provides that the adjacent geometrically cells (minterms) are adjacent in sense of Hamming distance, they differ in one Boolean value only

True minterm

False minterm

Please review

- Karnaugh Maps (Kmaps, for short) for 2,3,4 and 5 variables.
- The adjacent cells - geometrically and in the sense of Hamming distance.
- Enumeration of cells (minterms)
- Don’t care minterms and how to use them
- How to find prime implicants
- How to find Sum-of-Products (SOP) Covers of sets of true minterms with prime implicants.
- What are essential prime implicants and distinct vertices.
  - Distinct vertices are minterms that are covered by only one prime
  - Essential primes are primes that cover distinct vertices

Karnaugh Map

Sum of Products Logic

Draw and analyze the schematics

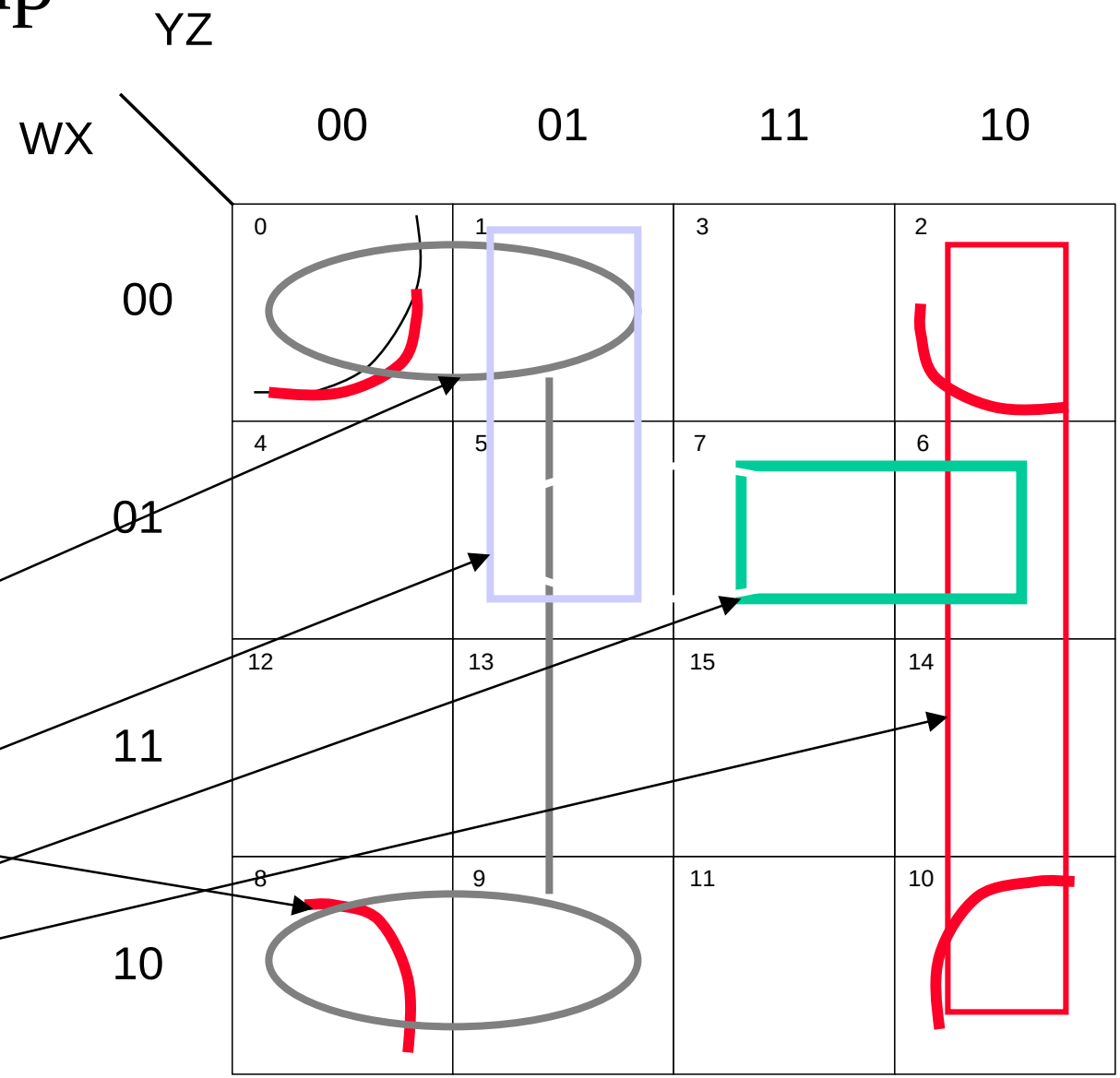
The cover shown here is:

X’Y’+X’Z’+

W’Y’Z+

W’XY+YZ’

This cover is not minimal



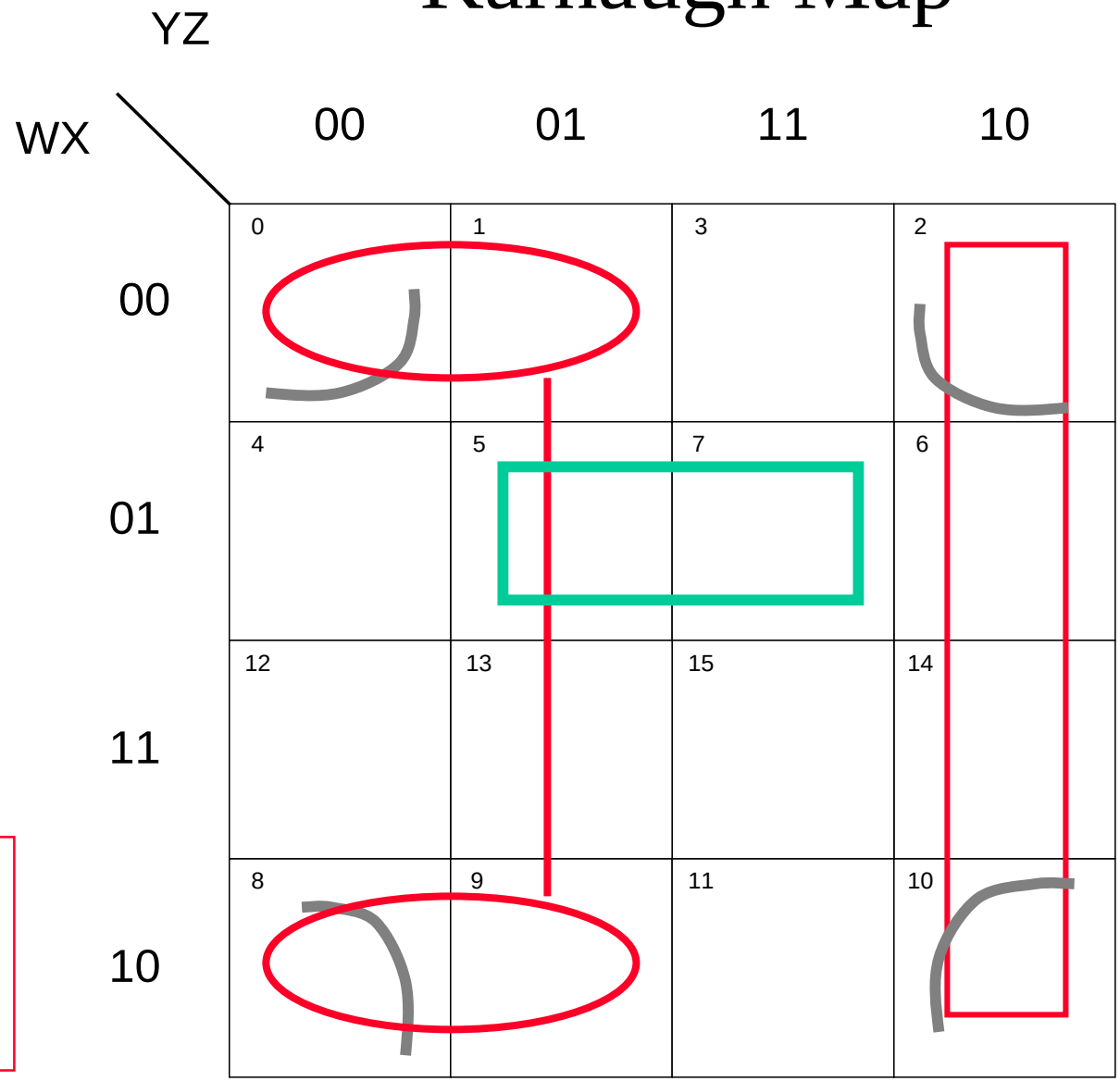
Karnaugh Map

A better cover has the following primes:

+X'Y' (essential) +

YZ' (essential)

+**W'XZ**(non -essential)



Observe that the grey prime is now redundant (X'Z')

Now you can prove that this cover is exact minimal solution

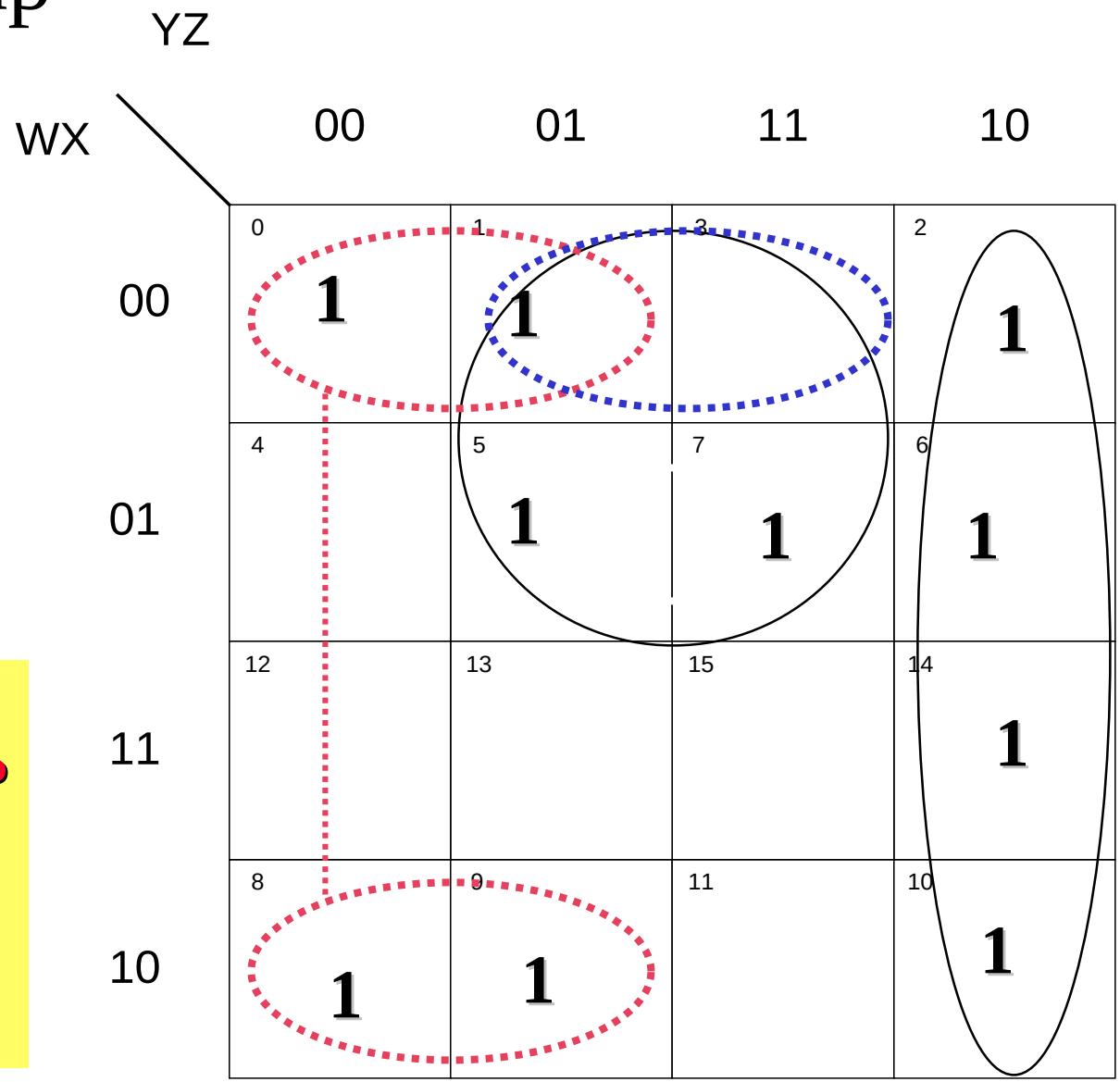
Covering, set covering, unate covering

Prime Implicant	[redacted]	0	1	2	5	6	7	8	9	10	14
(1, 5)	0-01		x		x						
(5, 7)	01-1				x		x				
(6, 7)	011-					x	x				
(0, 1, 8, 9)	-00-	x	x					x	x		
(0, 2, 8, 10)	-0-0	x		x				x		x	
(2, 6, 10, 14)	--10			x		x				x	x

Karnaugh Map

Exclusive Sum of Products Logic

Draw and analyze the schematics



Exclusive Sum of Products Logic ESOP is the following:

W'Y'⊕YZ' ⊕W'Z ⊕W'X'Z

Even/Odd Covering

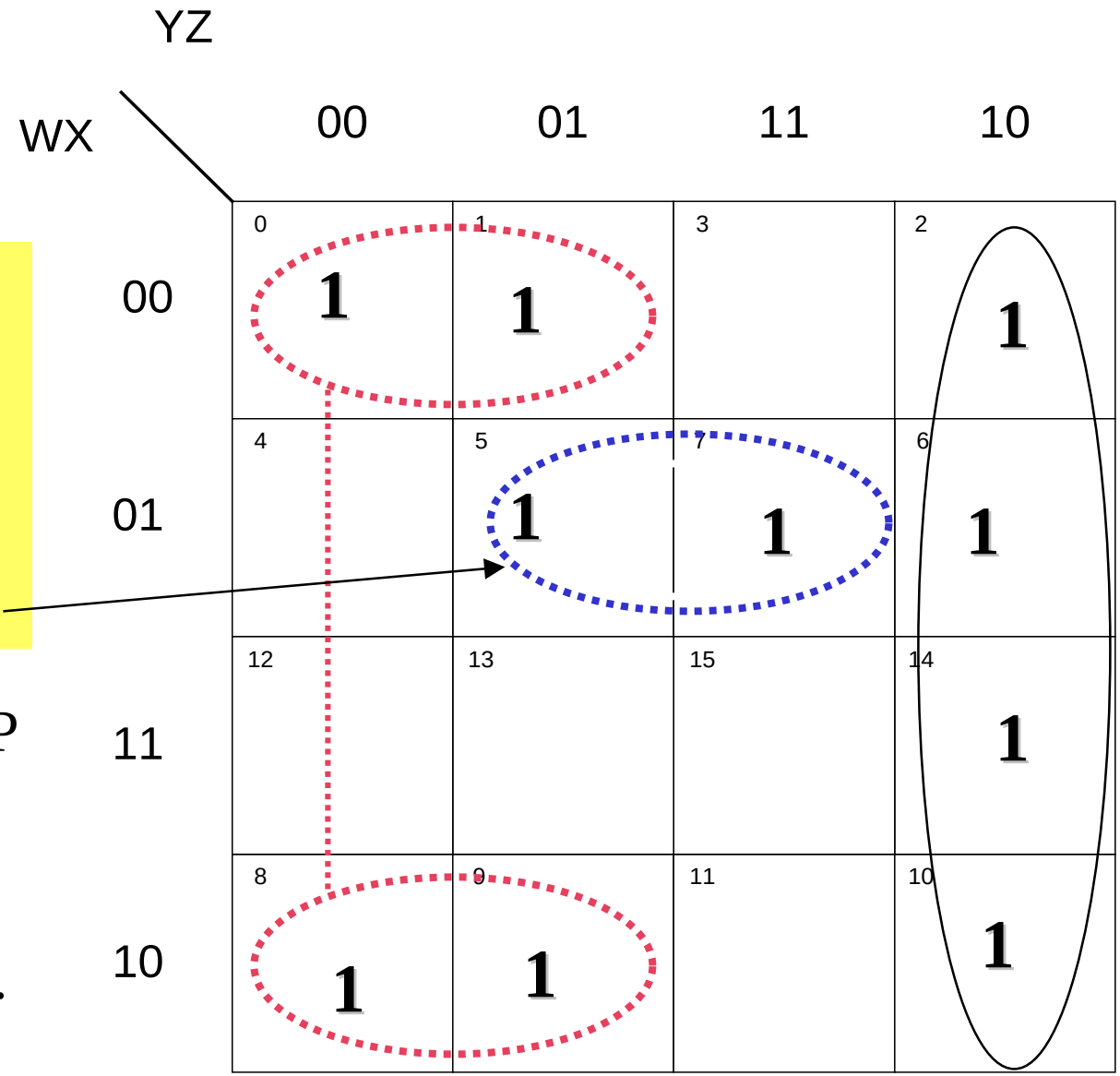
Exclusive Sum of Products Logic

Improvement:

$W'Y' \oplus YZ' \oplus W'Z \oplus W'X'Z = W'Y' \oplus YZ' \oplus W'Z(1 \oplus X') = W'Y' \oplus YZ' \oplus W'ZX$

This is the best ESOP

and in this case also the same groups are used in the best SOP. This is because the groups are disjoint.



Short Review of Exor Logic

- $A \oplus A = 0$
- $A \oplus A' = 1$
- $A \oplus 1 = A'$
- $A' \oplus 1 = A$
- $A \oplus 0 = A$
- $A \oplus B = B \oplus A$
- $A\ B = B\ A$

- $A(B \oplus C) = AB \oplus AC$
- $A+B = A \oplus B \oplus AB$
- $A+B = A \oplus B$ when $AB = 0$
- $A \oplus (B \oplus C) = (A \oplus B) \oplus C$
- $(A\ B)\ C = A\ (B\ C)$
- $A+B = A \oplus B \oplus AB =$
  $A \oplus B(1 \oplus A) = A \oplus BA'$

These rules are sufficient to minimize Exclusive Sum of Product expression for small number of variables

We will use these rules in the class for all kinds of reversible, quantum, optical, etc. logic. Try to remember them or put them to your “creepsheet”.

Natural number of the cell

WX \ YZ	00	01	11	10
00	0: **1**	1: **1**	3: **0**	2: **1**
01	4: **0**	5: **0**	7: **1**	6: **0**
11	12: **0**	13: **0**	15: **1**	14: **0**
10	8: **0**	9: **0**	11: **1**	10: **0**

This ESOP is : **W'X'⊕YZ**

Learn how to design graphically such solutions

What should you review for next time?

- Please review the Kmap, implicants and covering from any undergraduate textbook such as Roth or Katz
- Review basic Boolean algebra, De Morgan rules, factorization and flip-flops (D,T,JK).
- You should be able to take arbitrary Kmap of 5 variables, truth table, netlist or expression and convert it to a truth table or Kmap.
- Next you should be able to minimize it and draw a schematic with gates such as EXOR, NAND, NOR, etc.
- You should be able to reformulate problem expressed in English as a Boolean minimization or decision problem.
- SOP and ESOP logic and circuits.
- These are the minimum information to start practical design problems.

Homework number 1 (Due Monday)

- Generate a random, but rather complex (not trivial) function of three variables.
- Draw the Kmap for this function
- Find the minimal ESOP
- Draw the circuit using standard logic gates such as AND, NOT and EXOR for this circuit.
- Draw the quantum notation circuit with reversible Toffoli and Feynman gates for this circuit.