Karlsruher Institut für Technologie

ITIV

Examination SS 2014

Communication Systems and Protocols

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Communication Systems and Protocols
Date: 17.02.2014
Name: «Vorname» «Nachname»
Matriculation ID: «Matrikelnummer»
ID-No.: «LaufNr»

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Prerequisites for the examination

Aids

- Allowed aids for the examination are writing utensils, a ruler, a non-programmable calculator and a single sheet of A4 paper with self- and hand-written notes. Writing may be on a single side of the paper only. The use of own concept paper is not allowed.
- Use only indelible ink - use of pencils and red ink is prohibited.
- Other material than that mentioned above, is strictly forbidden. This includes any type of communication to other people.

Duration of the examination

120 minutes

Examination documents

The examination comprises 31 pages (including title page). Answers may be given in English or German. A mix of language within a single (sub)-task is not allowed. In your solution mark clearly which part of the task you are solving. Do not write on the backside of the solution sheets. If additional paper is needed ask the examination supervisor.

You will not be allowed to hand in your examination and leave the lecture hall in the last 30 minutes of the examination.

At the end of the examination: Stay at your seat and put all sheets into the envelope. Only sheets in the envelope will be corrected. We will collect the examination.

Task 1 Cyclic Redundancy Check

Task 1.1 CRC-Calculation

The bitstream 1011101000 shall be coded and transmitted using the generator polynomial $g(x) = x^5 + x^4 + x^2 + 1$.

A) Determine the bitstream as it is being transmitted.

Task 1.2 CRC-Error Detection

Given are the two generator polynomials:

1. $G_1(x) = x^5 + x^2 + 1$
2. $G_2(x) = x^5 + x^4 + x^2 + 1$

The data 10011011 should be secured for any odd number of errors. Which polynomial from these two would you choose? Justify your answer.

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Task 1.3 Parity Check

For protection of a block transmission parity bits are used as checksum. Blocks of always 8 bytes are protected by adding a parity bit for every byte and by adding additional parity bits for each column. **Even** parity is used.

A) What different type of errors can always be detected using block checking when using the protection scheme depicted above? Name three error types.

B) What types of errors can ALWAYS be corrected using block checking? Name two.

C) The following data was received. Check the parity bits and mark the bits that are interpreted as erroneous.

	Bit 0	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Parity
Byte 0	0	0	1	0	1	1	1	1	1
Byte 1	1	1	0	1	0	1	1	0	1
Byte 2	0	1	0	1	0	1	0	0	0
Byte 3	0	1	1	1	1	0	1	1	1
Byte 4	1	1	1	0	0	0	0	1	1
Byte 5	0	0	0	0	1	0	1	1	1
Byte 6	1	1	1	0	0	0	0	1	0
Byte 7	1	0	0	1	1	0	1	0	0
Parity	0	1	1	0	0	1	1	1	1

D) Is this information enough to reconstruct the original data? If yes give the original bytes that were sent. If no, give reason why this is not possible?

Task 1.4 General Questions

A) The communication in a system consisting of a sensor, a connection and a microcontroller shall be secured for errors. The sensor measures 28 bytes of data every 20 ms that should be sent in one transfer. The bandwidth of the connection is 13000 bit/sec. For the error detection the choice is between CRC16, CRC32, CRC64 and a block code that protects eight bit per row. What error protection is implementable in the given system?

B) Name three possible ways for error handling and sort them by the amount of overhead added to the communication in the case of a single bit error. Assume 128 bit of data that should be sent over a bus and additional redundant bits that can be used to protect the data. Justify your answer; an estimation of the overhead is sufficient.

Task 2 Media Access

Task 2.1 Transmission

A) Name two different types of transmission according to their direction and explain them shortly.

Task 2.2 Multiple use of media

A) Name four different types of Multiplexing schemes. Explain them shortly.

B) How many Walsh-functions are needed for the simultaneous transmission of several Nodes? Give a formula depending on N Nodes or explain.

C) Calculate the Walsh-functions for a transmission of four nodes, using the substitution scheme 0 = +1 and 1 = -1.

Function 1				
Function 2				
Function 3				
Function 4				

Table 2.1: Walsh Functions

For a CDMA access scheme three chips of each Walsh-function from the subtask above got lost. Sending the bits listed in **Fehler! Verweisquelle konnte nicht gefunden werden.** the signal **0 0 -4 0** can be measured on the medium.

Node	send bit
A	**1**
B	**0**
C	**1**
D	**0**

Node	Original Walsh-function			
A				**-1**
B		**-1**		
C		**-1**		
D				**+1**

Table 2.2: CDMA scheme using Walsh-functions

D) CompleteTable 2.2 with the correct Walsh Functions that are used by the nodes. Justify your answer by giving all your calculation steps or your complete reasoning.

Task 2.3 Arbitration

A) For the arbitration of four nodes a Polling model is used. Draw a Polling model with four nodes using an extra centralized Arbiter.
Label all used signals. Give a short explanation (one sentence) of each of the different types of signals used in this scheme. Mark the arbiter in your scheme and briefly explain its basic function (ca. 3 sentences).

A system with four nodes is using a wired-AND CSMA/CA scheme to determine the order of the transmission. The identifiers of the nodes are as follows:

	LSB									MSB
Node 0:	0	1	0	0	1	0	1	0	0	0
Node 1:	1	0	1	1	0	1	0	1	0	0
Node 2:	1	1	0	1	0	0	0	1	1	0
Node 3:	0	0	1	1	1	0	1	0	0	0

Table 2.3: CSMA/CA Node Identifiers

B) Draw the signal flow for the arbitration if all nodes want to send a message simultaneously. The nodes start the transmission by sending the identifiers of **Fehler! Verweisquelle konnte nicht gefunden werden.**.

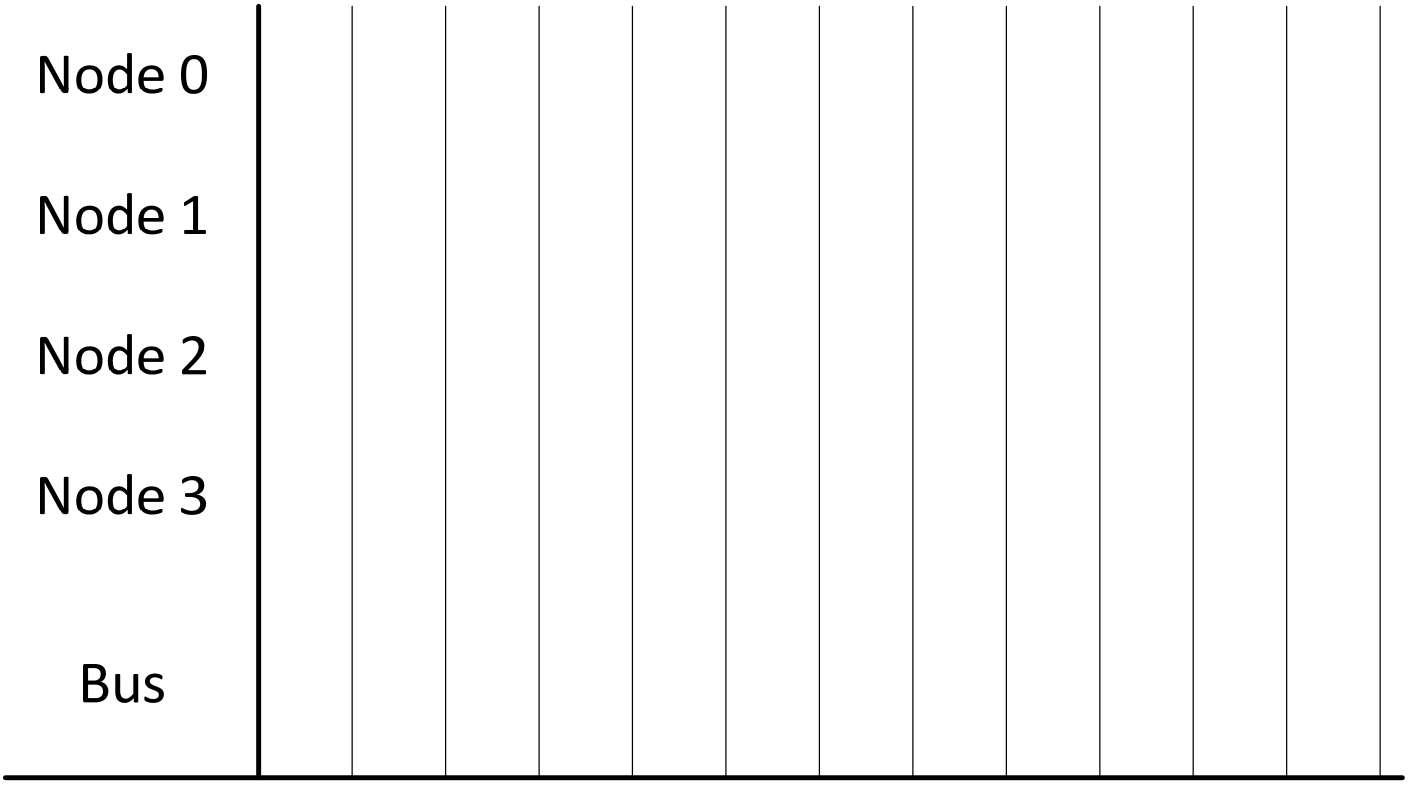


Figure 2.1: Signal flow for CSMA/CA

Task 3 Synchronization

Task 3.1 General Questions

A) An Ethernet connection uses a 4B5B line code. What is the purpose of the code?

B) Why is synchronization required during a data transfer?

C) Name three synchronization methods and explain them shortly.

Task 3.2 Synchronization in Serial Communication

The lighting equipment on a stage is controlled via a serial communication connection running at 250KBit/s in 8N2 mode. 8N2 means that each transmitted byte is preceded by one start bit and succeeded by two stop bits.

Data on the serial connection is transmitted in frames with a fixed composition:

Each frame starts with a break (a low level on the signal line) with a length of 88 µs and a following mark (a high level on the signal line) of 8 µs. Subsequently one byte of header follows and finally 512 bytes of data are transmitted. (Hint 1KBit = 1000 Bit)

A) Calculate the maximum rate at which frames can be transmitted.

Each node of the lighting equipment required to receive the serial data signal contains a microcontroller for this task. A typical microcontroller peripheral used to receive a serial signal is a UART. Normally it uses 16x oversampling of the signal line to eliminate any unwanted glitches.

B) Calculate the minimum operation frequency of the microcontroller when it is required to receive the serial data signal from above with its internal UART.

A simpler serial receiver performs only 6 time oversampling. It takes three consecutive samples in the middle of each bit. A majority voting is used to determine the final bit value. The following diagram shows the serial signal at the receiver while a noisy header byte is received.

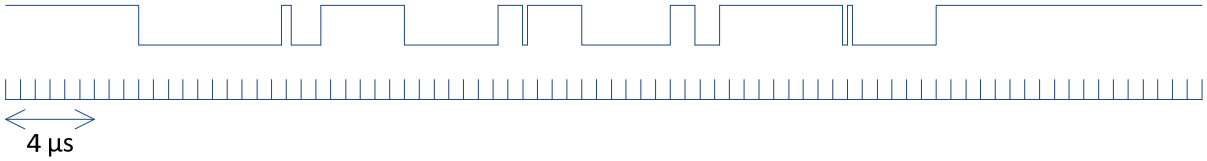


Figure 3.1: Signal flow for CSMA/CA

C) Mark the bit boundaries and determine the received bit values. Finally determine the received header byte in hexadecimal representation. (Hint: Bytes are transmitted LSB first.)

D) What is the maximum allowed duration of a glitch in the received signal when an error free reception of the signal is required? Use the receiver specification from the previous task (250 Kbit/s, 6x oversampling, 3 consecutive samples) and give all calculation steps. (Hint 1KBit = 1000 Bit)

E) Fast and modern interface standards like e.g. PCI-Express or SATA predominantly use serial communication techniques. Name three advantages over a parallel communication?

F) Typically in high speed serial communications a 4B5B code or something similar is used. Name and explain an advantage over the Start-Stop Method previously discussed.

Task 4 Data Transmission

Task 4.1 General questions

A) How does baseband differ from broadband? Name two differences.

Task 4.2 System bit

A) The bandwidth of a video signal is 4.5MHz. This signal is to be transmitted using PCM (Pulse code modulation) with the number of quantization levels Q=1024. The sampling rate should be 20% higher than the Nyquist rate. Calculate the system bit rate.

Task 4.3 Line Codes

A) Explain the Manchester Code encoding schemes and name one general application where it is applied.

B) Draw the digital signals for the bit string 010 101 111 000 011 using each of the NRZ, Manchester, and differential Manchester digital encoding schemes. Label the bit values that are sent within each encoding diagram.

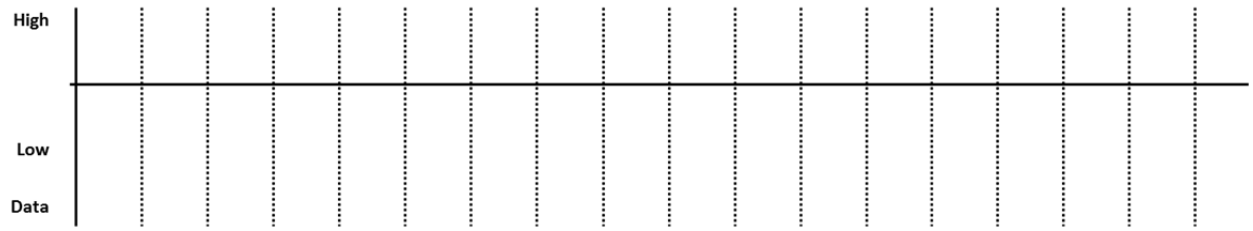


Figure 4.1: NRZ

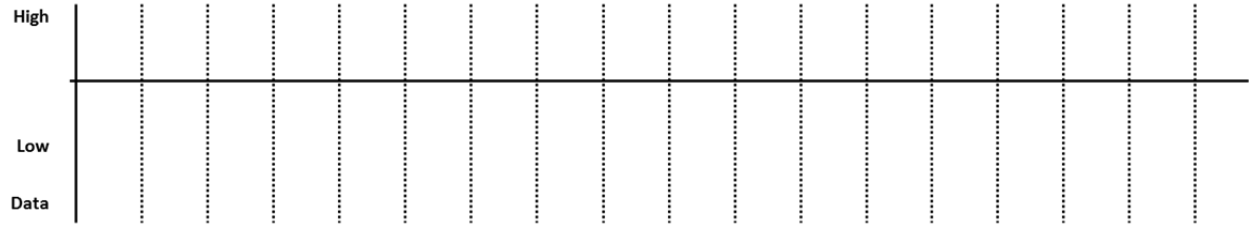


Figure 4.2: Manchester Code

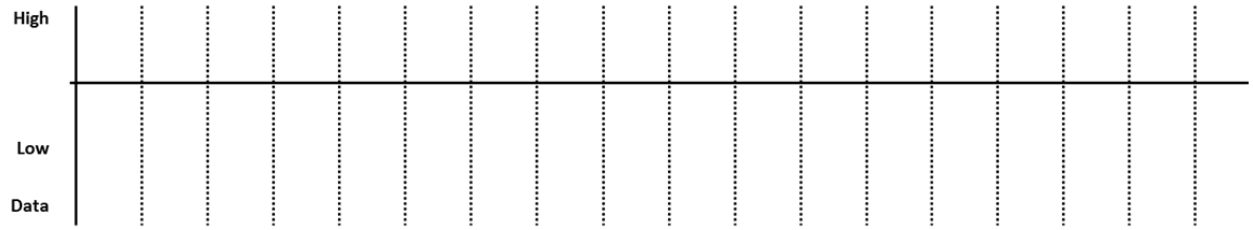


Figure 4.3: Differential Manchester Code

C) Name three important properties of line codes.

Task 4.4 Arbitration

A) Name one common known application where CSMA/CD protocol is applied?

B) Draw a sequence diagram (flowchart) of one node transmitting a message using the CSMA/CD protocol and explain each step in one sentence.

C) Name two advantages and two limitations of CSMA/CD protocols.

Task 4.5 Corrupted clock lines

A) Given is an asynchronous communication system with one data line and one clock line. Data is transmitted using NRZ encoding. If the clock line is corrupted, is it still possible to transfer data? Justify your answer.

Task 5 Physics

Task 5.1 General questions

A) Name two kinds of wirebased electrical media that can provide protection against crosstalk. Explain shortly how interferences can be eliminated in these.

B) Explain the the basic working principal of bus drivers based on Tristate Gates and Open Collector based bus drivers. Discuss the advantages and disadvantages for both driver variants.

C) Explain TTL-Level and the different High/Low thresholds.

Task 5.2 Sampling

A) What is necessary to fully reconstruct an analog signal when sampling it of a physical medium? How are artefacts avoidable?

B) Draw a Sample&Hold. Why are they needed for A/D-conversion?

Task 5.3 Model of Signal Lines

How are long signal lines modeled? Draw the equivalent circuit diagram of a long line. Explain why and how it is used. Give the formula for the impedance (loss-less case).

Task 5.4 Reflection on wires

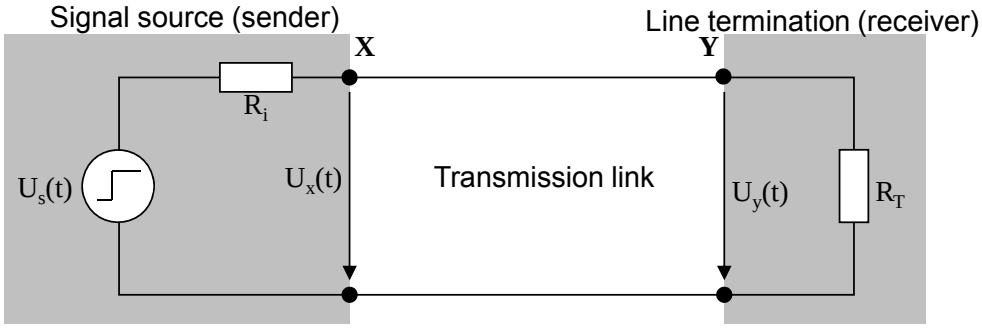


Figure 5.1: Test Setup

A) In Figure 5.1 an assembly is considered, consisting of a voltage source with an internal resistance $R_i = 600\Omega$ as sender and a receiver with $R_T = 300\Omega$. The DC resistance of the line is zero. Calculate the value of the wave resistance at the time of t=0.

At the time t=0 the voltage U_s of the sender changes from 0V to 5V and is constant afterwards. The propagation time of a wave on the wire is t_d. The voltage u_x at the time of t=0 is $U_x(0)=3V$.

B) Calculate the reflection factors on both sides of the test setup in Figure 5.1.

C) Which voltage value appears at the points X and Y after t = 1?

D) Which voltage value appears at the points X and Y after an infinite amount of time and why?

Task 6 Practical Aspects of Communication Systems

Task 6.1 General Questions

A) Name 4 multi master capable bus systems:

B) Briefly describe the difference between isochronous transmission and bulk transfers of the USB specification:

C) Name 3 advantages of CAN over USB:

D) Name 3 advantages of USB over CAN

Task 6.2 USB Protocol

Design an USB topology with the given minimal bandwidth requirements for the devices listed in table 2. For cost reasons use the lowest possible USB mode for each connection. All USB modes are listed in table 1 as a reference.

Table 1: Reference of USB modes

USB Mode	Shortcut	Max. Bandwidth	USB Generation
Low Speed	LS	1.5 Mbit/s	USB-1
Full Speed	FS	12.5 Mbit/s	USB-1
Hi-Speed	HS	480 Mbit/s	USB-2
SuperSpeed	SS	5 Gbit/s	USB-3

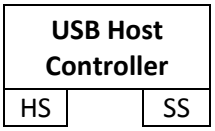
A) Fill out the column for USB generation / mode of table 2 with the minimal needed USB mode and it's corresponding generation for the given devices and their maximum data rate.

Table 2: USB Devices to use

Name	Device	Max. Data Rate of Device	USB Gen. / Mode
A	USB Storage Device	640 Mbit/s	
B	USB Camera Device	5 Mbit/s	
C	DVB Video Receiver	15 Mbit/s	
D	Fast Ethernet Controller	100 Mbit/s	
E	Gigabit Ethernet Controller	1 Gbit/s	
F	USB to Serial Adapter with 1.5 Mbit/s UART	1.5 Mbit/s	
G	USB Keyboard	8 Kbit/s	

The USB host controller has 1 port supporting LS, FS, HS and SS modes and 1 port supporting LS, FS and HS modes. 1 USB-3 hub, 1 USB-2 hub and 1 USB-1 hub with **3 ports each** are available.

B) Draw the topology tree with all devices of table 2 and the above listed hubs. Tag every connection (bus segment) with an identifier / number and the USB mode you chose.



C) Calculate the bandwidth utilization for each bus segment of your topology, if all devices are operating at their full speed. Assume a general protocol overhead of 20 %. Give all steps of your solution and use your assigned identifier.

D) An USB topology should be used in a partly real-time capable environment. One connected device has hard real-time requirements and therefore guaranteed latencies have to be ensured. Is this possible with an USB topology? Justify your answer.

Task 7 Networks

Task 7.1 OSI Reference Model

Figure 7-1 shows the 7 layers and the layer names of the OSI reference model

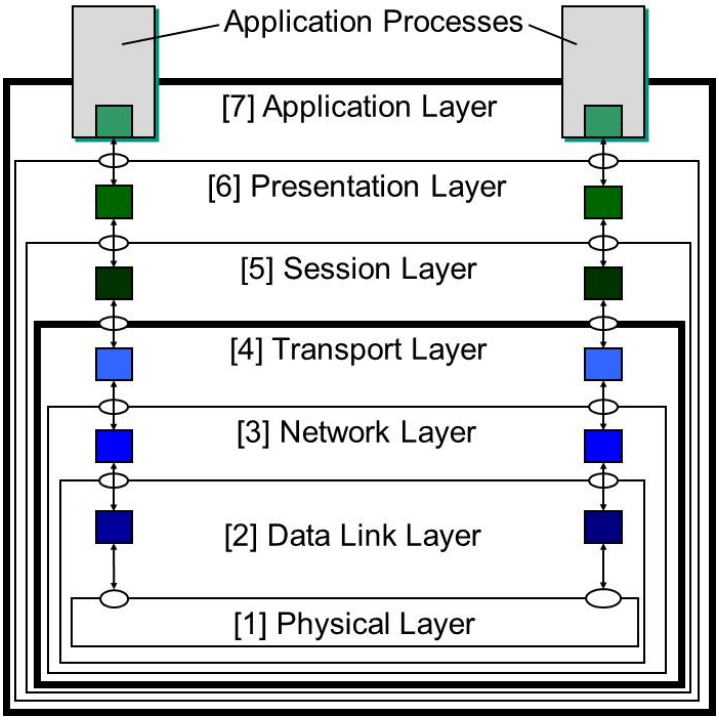


Figure 7-1: The 7 Layers of the OSI reference model

When communicating through a network, typically the application used in the end-node (e.g. personal computer), the operating system (OS) of the end-node, the hardware of the node and the switching components of the network are involved.

A) Mark all layers (with an X), that are realized by the respective component

Component	OSI Layer						
	1	2	3	4	5	6	7
Repeater							
Bridge							
Router							
Gateway							
Smartphone/Server							

B) Give one specific example (protocol, application …) for each layer of the internet reference model.

Application Layer:

Transport Layer:

Internet Layer:

Network Layer:

C) What are the main differences between the OSI-reference model and the Internet reference model (Give at least two points.)

Task 7.2 Routing

A) What is the task of a routing mechanism

B) Why is adaptive routing referred to be more flexible than static routing

Figure 7-2 shows a 4x4 meshed network with bidirectional links for wormhole packet-switching communication.

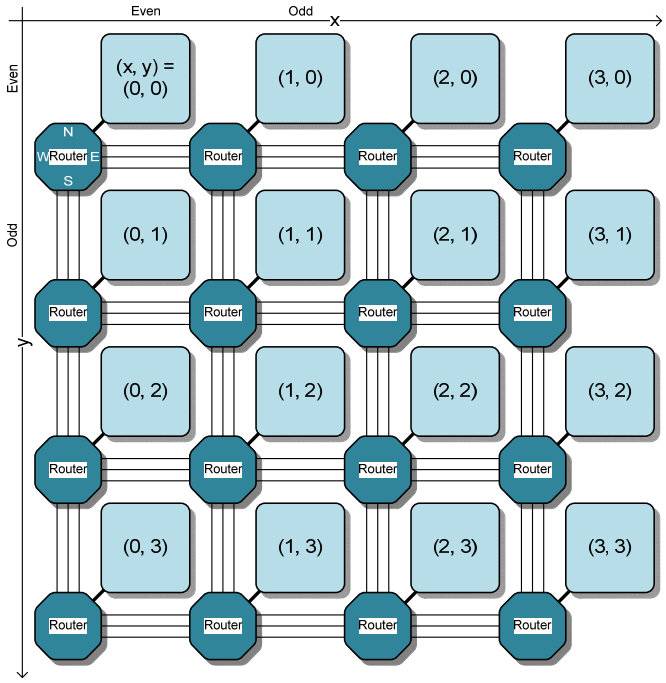


Figure 7-2: 4x4 meshed network

C) Which routers are passed by a packet sent from (x, y) = (0, 1) to (3, 3) using XY-Routing. Please provide the coordinates of the passed router in the order given by the transmission process.

D) Give a valid minimal path for a packet sent from (x, y) = (1, 1) to (3, 2) using Odd-Even-Turn Routing (only definition from CSP lecture is valid). Please provide the coordinates of the passed router in the order given by the transmission process.

E) Is there an invalid but minimal path for the transmission conditions, defined in D)? Justify your answer.

Task 7.3 Packet- vs. Circuit-Switching

The following table defines the properties of a packet- and a circuit-switching network.

Property	**Packet-Switching Network**	**Circuit-Switching Network**
Connection Setup Time	0 us (no setup required)	27 us
Max. Packet Size	100 flits	Arbitrary (not limited)
Packet Delay	100 $\frac{\text{ns}}{\text{flit}}$ * #flit + 1 us	10 $\frac{\text{ns}}{\text{flit}}$ * #flit
Energy Consumption (Setup)	0 $\frac{\text{uJ}}{\text{flit}}$	1 $\frac{\text{uJ}}{\text{flit}}$
Energy Consump. (Transmission)	20 $\frac{\text{nJ}}{\text{flit}}$	2 $\frac{\text{nJ}}{\text{flit}}$

For a specific application, a dataset of 250 flits needs to be transmitted to the same receiver. Subsequently a new receiving node is selected for the next transmission.

Which network is to be more appropriate for this scenario? Justify your answer analytically!

A) The latency is the primary optimization goal:

B) Energy consumption the primary optimization goal: