Check Digits

Check Digits

A form of error detection.
A **check digit** is the final **digit** in a code of numbers.
It is calculated from all the other **digits** in the code.
Its purpose is to spot human errors on data entry.

(1) Check Digits are a way of ensuring that data has been entered and read correctly.

(2) Check Digits are Digits which are added to the ends of numbers and are calculated using the other digits in the number.

(3) Many different ways/methods/algorithms are used to generate Check Digits

(4) One Simple Algorithm is summing all of the digits and taking the modulus 10

(5) So, if you have a code of: 1763

(6) The Check Digit will be:- 7 and you get 17637

(7) This is from (1+7+6+3) MOD 10 = 17 MOD 10 = 7

Remember the modulus is the remainder if two numbers are divided by each other

Examples where Check Digits are used in Real Life

(1) ISBN Numbers   **ISBN-13**   **978-1-84078-596-<u>8</u>**   **The last digit here is the Check Digit**

(2) Bar/Product Codes   **0 705 632 441 94<u>7</u>**   **The last digit here is the Check Digit**

(3) Credit Cards   **6360 5495 5110 999<u>1</u>**   **The last digit here is the Check Digit**

Parity Bits

Parity Bit

(1)   A Parity Bit is a type of Check Digit .

(2) It is an extra bit added to a data message (made up of binary data) at its origin (i.e before the data is transmitted) .
And then scrutinised at the receiving end to determine whether an error has occurred in transmission,

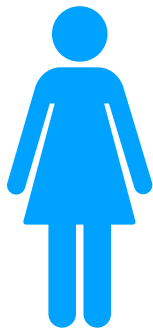## (3) We have:-

(I)   **Even Parity** - here an extra bit is added to construct a string with **an even number of 1s'**.

(I)   **Odd Parity** - here an extra bit is added to construct a string with **an odd number of 1s'**.

Even Parity

Alice

1010 010

(1) Alice wants to transmit
this string.
The string has 7 bits

Bob

(2) This string has
3 1s' in it.
So the string has an odd
number of 1s'.

1010 010

(9) 1010 010 **1**

(3) Now, in even parity a string has to be created with an even number of 1s'

(4) So, in order to fulfil the criteria of even parity,
a '1' is added to the end of the string before transmission..
This extra bit is the parity bit.

(10) At Bob's end
a calculation is
performed to
determine the
parity bit.

(11) 1010 010   1

(5) 1010 010 **1**

(12) At Bob's end a value of
'1' is calculated and that
matches the value that was
received.

(6) This results in an 8-bit string with an even number of 1s.

(7) We can see that the string has 4 1s' in it.

(13) So, we will say
here that the string
was correctly
transmitted

(8) And this 8-bit string which includes the extra parity bit is passed to Bob

Another Example of Even Parity Detecting Correct

Alice

Bob

1010 000

(1) Alice wants to transmit this string. The string has 7 bits

(2) This string has 2 1s' in it. So the string has an even number of 1s'.

(9) 1010 000 0

1010 000

(3) Now, in even parity a string has to be created with an even number of 1s'

**(4) So, in order to fulfil the criteria of even parity, a '0' is added to the end of the string before transmission.
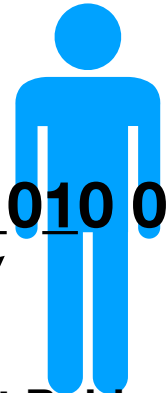This extra bit is the parity bit**

(5) 1010 000 0

(6) This results in an 8-bit string with an even number of 1s.

(7) We can see that the string has 2 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob

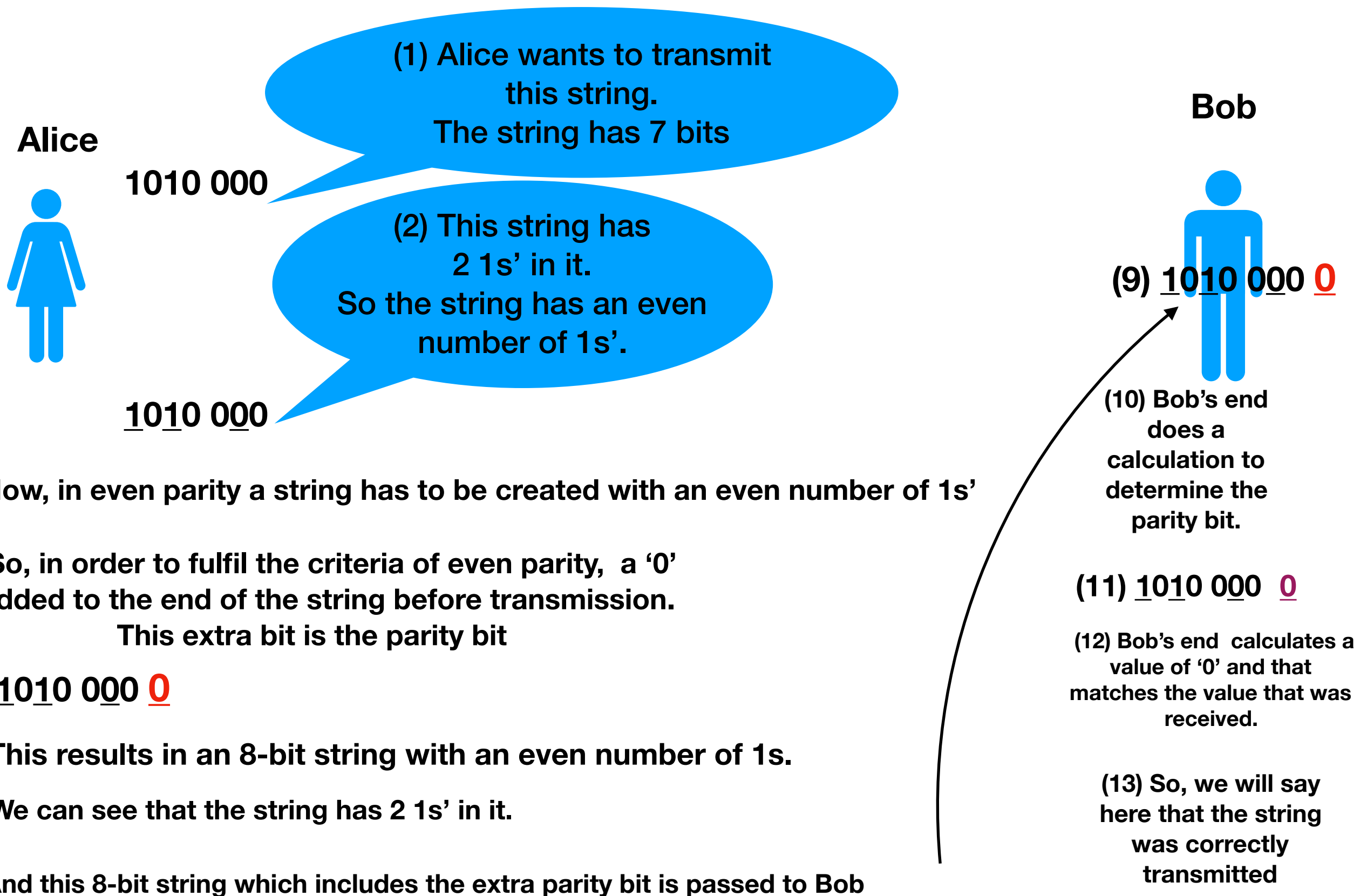**(10) Bob's end does a calculation to determine the parity bit.**

(11) 1010 000 0

(12) Bob's end calculates a value of '0' and that matches the value that was received.

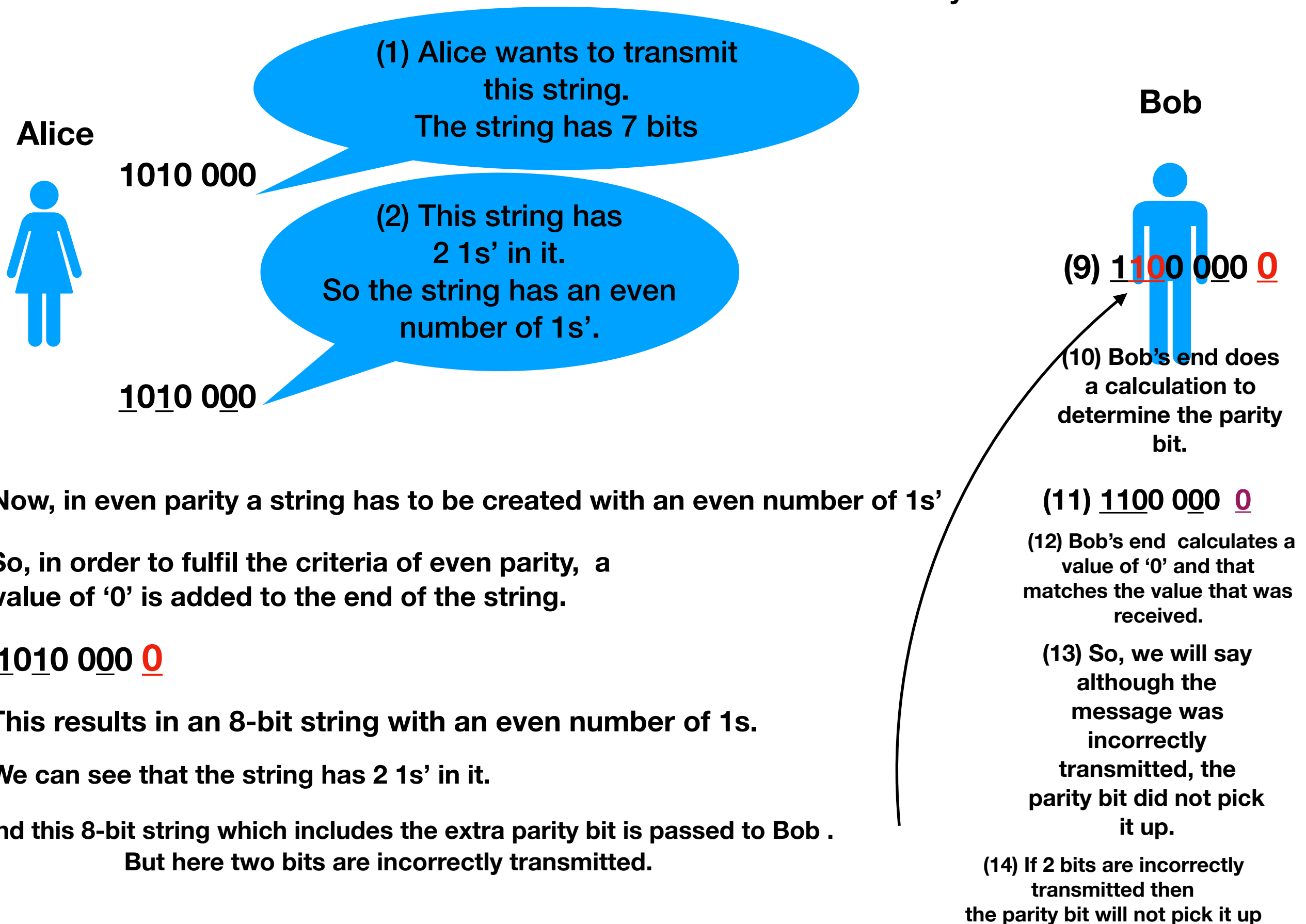**(13) So, we will say here that the string was correctly transmitted**

Detecting an Error in Transmission of Data with Even Parity.
This can happen only if one bit is sent/read incorrectly.

Alice

Bob

1010 000

(1) Alice wants to transmit this string.
The string has 7 bits

(2) This string has 2 1s' in it.
So the string has an even number of 1s'.

(9) 1110 000 0

1010 000

(3) Now, in even parity a string has to be created with an even number of 1s'

(10) Bob's end does a calculation to determine the parity bit.

(4) So, in order to fulfil the criteria of even parity, a value of '0' is added to the end of the string before transmission.
This extra bit is a parity bit

(11) 1110 000 1

(12) Bob's end calculates a value of '1' and that does not match the value that was received.

(5) 1010 000 0

(6) This results in an 8-bit string with an even number of 1s.

(13) So, we will say here that the string was not correctly transmitted

(7) We can see that the string has 2 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob .
This string passed to Bob has an error in it.

(14) Only if one bit of the binary string is sent incorrectly,
Then the computer can pick up on the error.

Incorrect Message sent but No Error Detected with Even Parity Bit - if 2 bits are transmitted/read/sent incorrectly

Alice

1010 000

(1) Alice wants to transmit this string.
The string has 7 bits

(2) This string has 2 1s' in it.
So the string has an even number of 1s'.

1010 000

Bob

(9) 1100 000 0

(10) Bob's end does a calculation to determine the parity bit.

(3) Now, in even parity a string has to be created with an even number of 1s'

(4) So, in order to fulfil the criteria of even parity, a value of '0' is added to the end of the string.

(5) 1010 000 0

(6) This results in an 8-bit string with an even number of 1s.

(7) We can see that the string has 2 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob .
But here two bits are incorrectly transmitted.

(11) 1100 000 0

(12) Bob's end calculates a value of '0' and that matches the value that was received.

(13) So, we will say although the message was incorrectly transmitted, the parity bit did not pick it up.

(14) If 2 bits are incorrectly transmitted then the parity bit will not pick it up

Questions & Answers

An even parity bit has been added to the end of three 7-bit binary codes to create the 8-bit binary codes below. Identify and explain which code contains an error

Code 1

10101011

Code 2

10100101

Code 3

10010011

Questions & Answers

An even parity bit has been added to the end of three 7-bit binary codes to create the 8-bit binary codes below. Identify and explain which code contains an error

Code 1	Code 2	Code 3
10101011	10100101	10010011

10101011

The last digit is the parity bit.

Code 1 has 5 1s'

But in even parity you Need an even number of 1s'

So this Code 1 contains an error'

10100101

The last digit is the parity bit.

Code 2 has 4 1s'

And in even parity you Need an even number of 1s'

So this Code 2 does not contain an error'

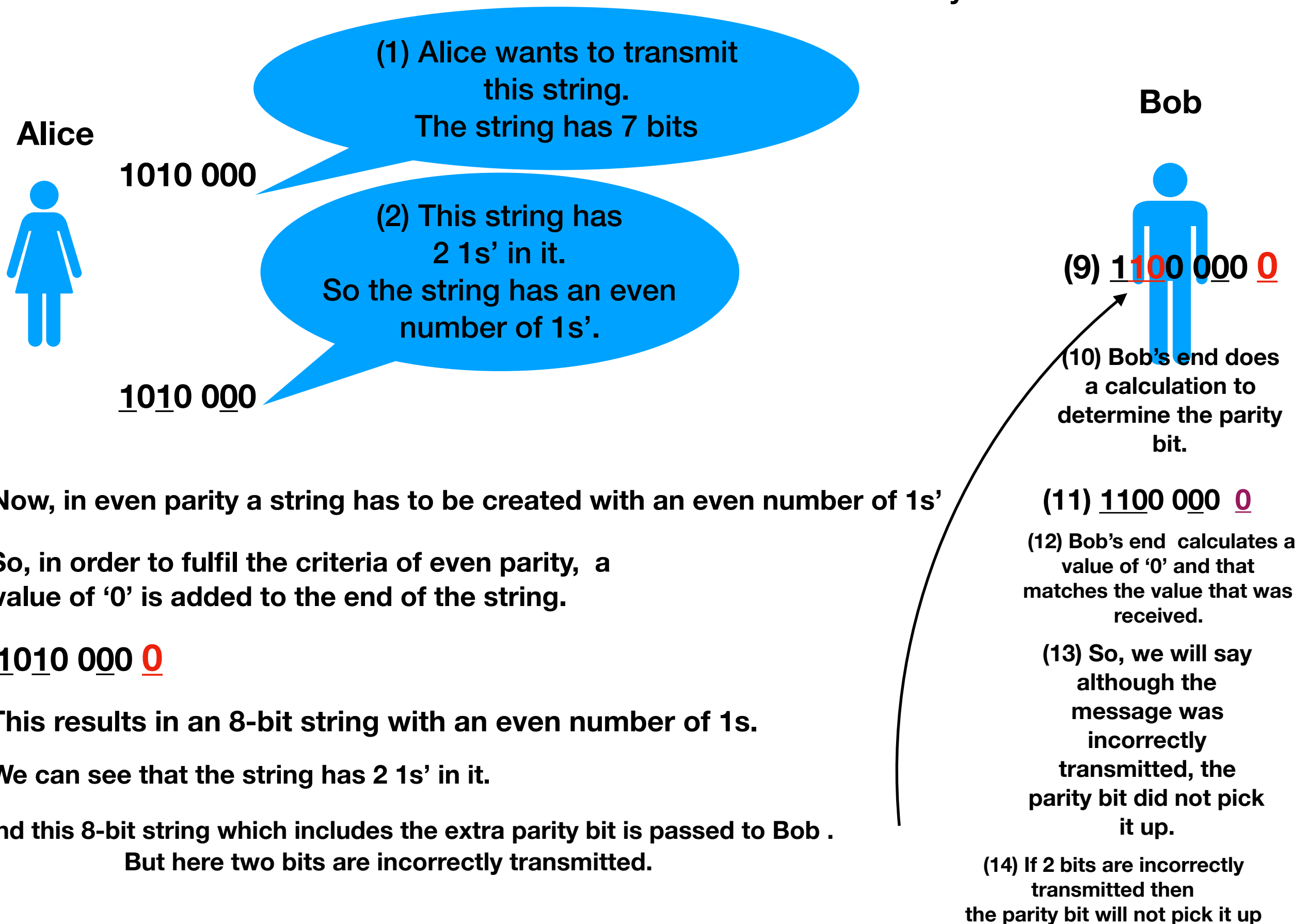**10010011**

The last digit is the parity bit.

Code 3 has 4 1s'

And in even parity you Need an even number of 1s'

So this Code 3 does not contain an error'

Question

Explain how a binary code containing a parity bit can be read incorrectly without any errors being detected

Incorrect Message sent but No Error Detected with Even Parity Bit - if 2 bits are transmitted/read/sent incorrectly

Alice

1010 000

**(1) Alice wants to transmit this string.
The string has 7 bits**

**(2) This string has 2 1s' in it.
So the string has an even number of 1s'.**

1010 000

Bob

(9) 1100 000 0

(10) Bob's end does a calculation to determine the parity bit.

(3) Now, in even parity a string has to be created with an even number of 1s'

(4) So, in order to fulfil the criteria of even parity, a value of '0' is added to the end of the string.

(5) 1010 000 0

(6) This results in an 8-bit string with an even number of 1s.

(7) We can see that the string has 2 1s' in it.

**(8) And this 8-bit string which includes the extra parity bit is passed to Bob .
But here two bits are incorrectly transmitted.**

(11) 1100 000 0

(12) Bob's end calculates a value of '0' and that matches the value that was received.

(13) So, we will say although the message was incorrectly transmitted, the parity bit did not pick it up.

(14) If 2 bits are incorrectly transmitted then the parity bit will not pick it up

Questions & Answers

Explain how a binary code containing a parity bit can be read incorrectly without any errors being detected

If 2 bits are incorrectly transmitted then the parity bit will not pick it up

Parity Bits

Parity Bit

(1) A Parity Bit is a type of Check Digit .

(2) It is an extra bit added to a data message (made up of binary data) at its origin (i.e before the data is transmitted) .

And then scrutinised at the receiving end to determine whether an error has occurred in transmission,

(3) We have:-

(I)   **Even Parity** - here an extra bit is added to construct a string
with **an even number of 1s'.**

(I)   **Odd Parity** - here an extra bit is added to construct a string with
an odd number of 1s'.

Odd Parity

Another Example of Odd Parity Detecting Correct Transmission

Alice

Bob

(1) Alice wants to transmit this string.
The string has 7 bits

1010 000

(2) This string has 2 1s' in it.
So the string has an even number of 1s'.

(9) 1010 000 **1**

1010 000

(3) Now, in odd parity a string has to be created with an odd number of 1s'

(4) So, in order to fulfil the criteria of even parity, a '1' is added to the end of the string before transmission.
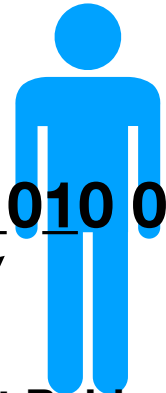This extra bit is the parity bit

(5) 1010 000 **1**

(6) This results in an 8-bit string with an odd number of 1s.

(7) We can see that the string has 3 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob
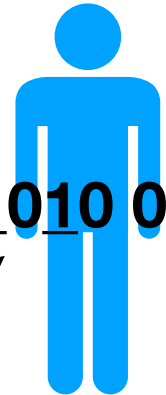
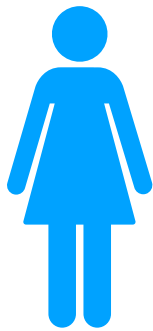(10) Bob's end does a calculation to determine the parity bit.

(11) 1010 000 **1**

(12) Bob's end calculates a value of '1' and that matches the value that was received.

(13) So, we will say here that the string was correctly transmitted

Detecting an Error in Transmission of Data with Odd Parity.
This can happen only if one bit is sent/read incorrectly.

Alice

1010 000

(1) Alice wants to transmit this string.
The string has 7 bits

(2) This string has 2 1s' in it.
So the string has an even number of 1s'.

1010 000

(3) Now, in odd parity a string has to be created with an odd number of 1s'

(4) So, in order to fulfil the criteria of even parity, a value of '0' is added to the end of the string before transmission.
**This extra bit is a parity bit**

(5) 1010 000 1

(6) This results in an 8-bit string with an odd number of 1s.

(7) We can see that the string has 3 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob .
This string passed to Bob has an error in it.

Bob

(9) 1110 000 1

(10) Bob's end does a calculation to determine the parity bit.

(11) 1110 000 0

(12) Bob's end calculates a value of '0' and that does not match the value that was received.

(13) So, we will say here that the string was not correctly transmitted

(14) Only if one bit of the binary string is sent incorrectly,
Then the computer can pick up on the error.

Incorrect Message sent but No Error Detected with Even Parity Bit - if 2 bits are transmitted/read/sent incorrectly

Alice

Bob

1010 000

(1) Alice wants to transmit this string.
The string has 7 bits

(2) This string has 2 1s' in it.
So the string has an even number of 1s'.

1010 000

(9) 1100 000 1

(10) Bob's end does a calculation to determine the parity bit.

(3) Now, in odd parity a string has to be created with an odd number of 1s'

(4) So, in order to fulfil the criteria of odd parity, a value of '1' is added to the end of the string.

(5) 1010 000 1

(6) This results in an 8-bit string with an odd number of 1s.

(7) We can see that the string has 3 1s' in it.

(8) And this 8-bit string which includes the extra parity bit is passed to Bob .
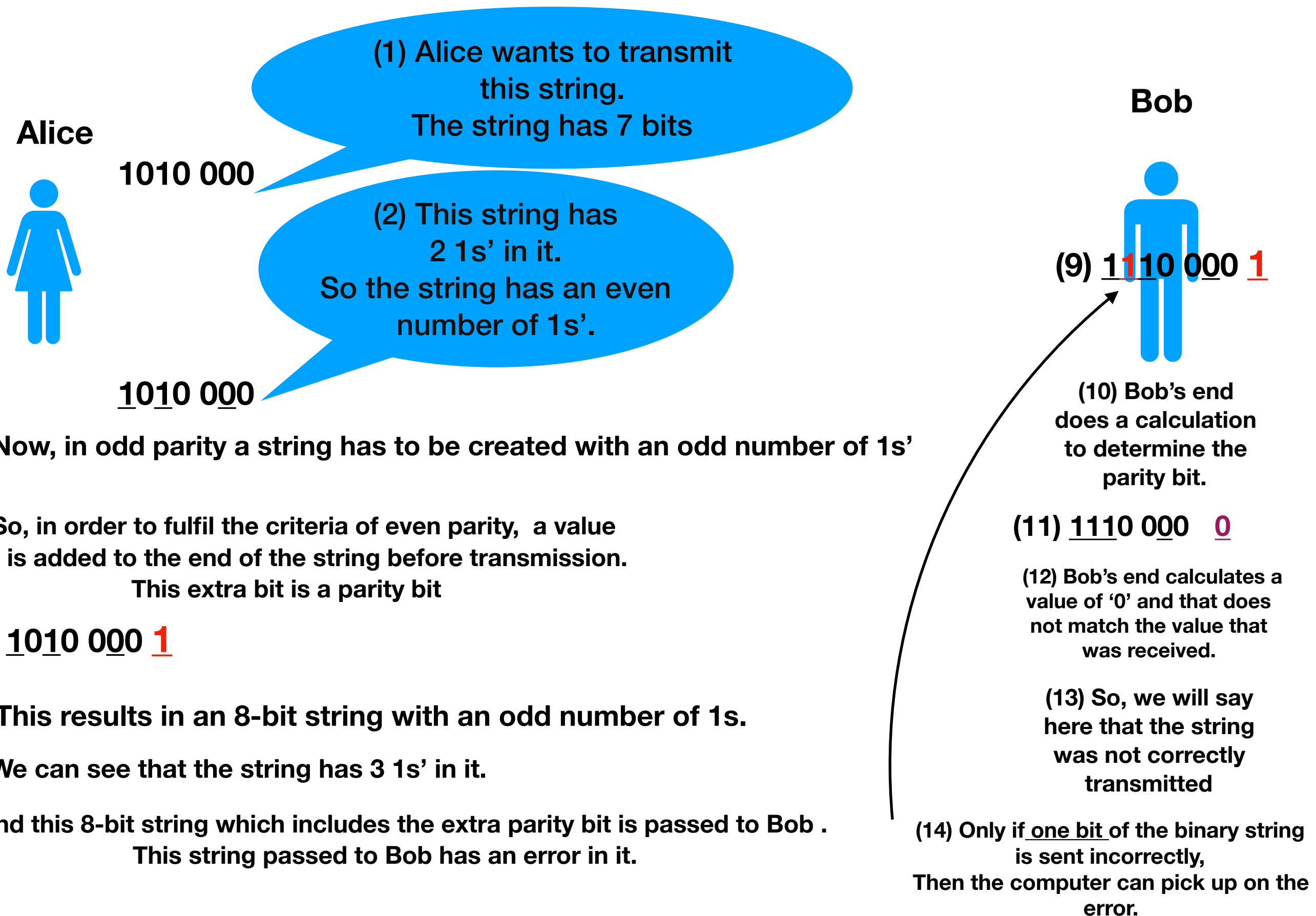But here two bits are incorrectly transmitted.

(11) 1100 000 1

(12) Bob's end calculates a value of '1' and that matches the value that was received.

(13) So, we will say although the message was incorrectly transmitted, the parity bit did not pick it up.

(14) If 2 bits are incorrectly transmitted then the parity bit will not pick it up