Error Correction Techniques in Computer Networks

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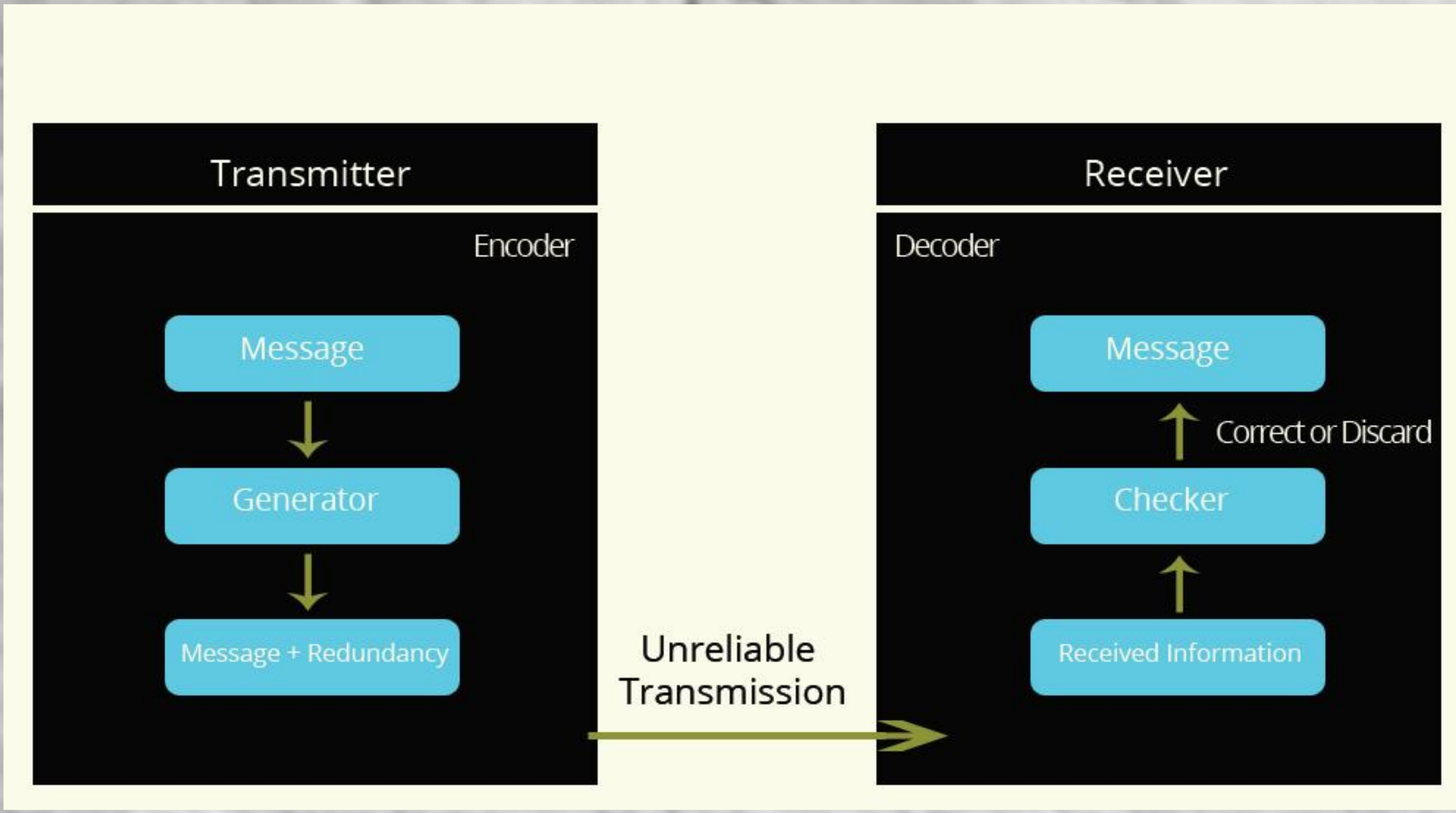
Outline

- Error?
- Error Detection
- Error Correction
  - Backward Error Correction
  - Forward Error Correction

Error?

- Corruption of data during transmission
  - **Bits lost**
  - **Bits changed**
  - **Bits added**
- Types of errors;
  - **Single bit errors**
  - **Multiple bit errors**
  - **Burst errors**

Error in Network



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Error Detection

- Error Detection techniques allow the destination to detect errors.
- Sometimes **undetected errors** will still remain but **the goal is to minimize** these errors.

Error Detection

- To detect and correct errors, **enough redundancy bits need to be sent** with data.
- Redundancy bits are the extra bits sent by source to inform destination about the data sent.

Error Detection

- Parity Check
- Cyclic Redundancy Check (based on binary division)
- Checksum
- Hamming Distance Check

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Backward Error Correction

- Known as ***Automatic Repeat Request(ARR)***
- Reciever device sends a request to the source device to re-send the data after detecting the error or errors
- More often used because it requires less bandwidth
- A return channel is needed for backward error correction

Backward Error Correction

- There are two ways to overcome the errors
  - **Positive acknowledgement**

    Reciever returns confirmation of each block recieved correctly. The transmitter re-sends the block that is not acknowledged.
  - **Negative acknowledgement**

    Receiver returns a request to retransmit only the data with error

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Forward Error Correction

- This technique allows the receiver to detect and correct errors without asking the sender for retransmission
- The bandwidth requirement is higher but return channel is not needed
- Redundant data, sent by transmitter is also called ***error correction code***

Forward Error Correction

- Redundancy bits are added to the transmitted information using a predetermined information
- Each redundancy bit can be a function of many parts of original data or also can be nonsystematic

Forward Error Correction

- Example: **Democratic Voting**

Recieved Data	Interpreted as
000	0
001	0
010	0
011	0
100	1
101	1
110	1
111	0 error

Forward Error Correction

- Two main categories
  - Block Coding: Reed-Solomon Coding, Hamming Codes, Binary BCH
  - Convolutional Coding: Viterbi Algorithm

Forward Error Correction

- **Block Coding** works on fixed size packets of bits
- Mostly common used algorithm is ***Reed-Solomon***

Forward Error Correction

- A Reed-Solomon code is specified as RS(n,k) with s-bit symbols
- This means that the encoder takes *k* data symbols of *s* bits each and adds parity symbols to make an *n* symbol codeword
- There are *n-k* parity symbols of s bits each. A Reed-Solomon decoder can correct up to *t* symbols that contain errors in a codeword, where $2t = n-k$.

Forward Error Correction

- Example: A popular Reed-Solomon code is RS(255,223) with 8-bit symbols. Each codeword contains 255 code word bytes, of which 223 bytes are data and 32 bytes are parity. For this code:
- $n = 255$, $k = 223$, $s = 8$
- $2t = 32$, $t = 16$
- The decoder can correct any 16 symbol errors in the code word

Forward Error Correction

- **Convolutional codes** work on bit streams
- If desired a convolutional code can be turned into a block code
- Most widely used algorithm is Vitebi Algorithm if desired

Forward Error Correction

- **Viterbi** decoder examines an entire received data sequence of a given length at a time interval, then computes a metric for each path and makes a decision based on this metric

- One of the common metric used by Viterbi Algorithm for paths comparison is the Hamming distance metric, which is a bit-wise comparison between the received codeword and the allowable codeword

Conclusion

- Error Detection

  Parity Check, Cyclic Redundancy Check, Hamming Distance

- Error Correction

  Backward and Forward Error Correction

- Questions?
- Thanks…

ÖNEMLİ

Bu projeler lisansüstü öğrencilerinin hazırladığı çalışmalar olup tüm sorumluluk hazırlayan öğrencilere aittir. Öğrenciler hazırladığı projeye göre not almışlardır.