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Write a short note on Block Error Correction Codes, Convolutional Codes including BCH and Reed Solomon codes with example.

In computing, telecommunication, information theory, and coding theory, an error correction code, sometimes error correcting code, (ECC) is used for controlling errors in data over unreliable or noisy communication channels.[1][2] The central idea is the sender encodes the message with redundant information in the form of an ECC. The redundancy allows the receiver to detect a limited number of errors that may occur anywhere in the message, and often to correct these errors without retransmission. The American mathematician Richard Hamming pioneered this field in the 1940s and invented the first error-correcting code in 1950: the Hamming code.

ECC contrasts with error detection in that errors that are encountered can be corrected, not simply detected. The advantage is that a system using

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ECC does not require a reverse channel to request retransmission of data when an error occurs. The downside is that there is a fixed overhead that is added to the message, thereby requiring a higher forward-channel bandwidth. ECC is therefore applied in situations where retransmissions are costly or impossible, such as one-way communication links and when transmitting to multiple receivers in multicast. Long-latency connections also benefit; in the case of a satellite orbiting around Uranus, retransmission due to errors can create a delay of five hours. ECC information is usually added to mass storage devices to enable recovery of corrupted data, is widely used in modems, and is used on systems where the primary memory is ECC memory.

Using a new parity-check matrix, a class of convolutional codes with a designed free distance is introduced. This new class of codes has many characteristics of BCH block codes, therefore, we call these codes BCH convolutional codes.

Errors and Error Correcting Codes

Errors in data occur when bits get corrupted in the data. When bits are transmitted over the computer network, they are subject to get corrupted due to interference and network problems, leading to errors.

Error-correcting codes (ECC) are a sequence of numbers generated by specific algorithms for detecting and removing errors in data that has been transmitted over noisy channels. Error correcting codes ascertain the exact number of bits that has been corrupted as well as the location of the corrupted bits, within the limitations in algorithm.

ECCs can be broadly categorized into two types, block codes and convolution codes. Reed - Solomon Code is a type of block code.

Reed - Solomon Code
Reed - Solomon error correcting codes are one of the oldest codes that were introduced in 1960s by Irving S. Reed and Gustave Solomon. It is a subclass of non - binary BCH codes. BCH codes (Bose-Chaudhuri-Hocquenghem codes) are cyclic ECCs that are constructed using polynomials over data blocks.

A Reed - Solomon encoder accepts a block of data and adds redundant bits (parity bits) before transmitting it over noisy channels. On receiving the data, a decoder corrects the error depending upon the code characteristics.

Application Areas of Reed-Solomon Codes
The prominent application areas are -

Storage areas like CDs, DVDs, Blu-ray

Discs

High speed data transmission technologies such as DSL and WiMAX

High-speed modems
QR Codes
Broadcast systems such as satellite communications

Storage systems such as RAID 6
Parameters of Reed - Solomon Codes
A Reed-Solomon code is specified as RS(n,k).

Here, n is the block length which is recognizable by symbols, holding the relation, $n = 2m - 1$.
The message size is of k bits.

So the parity check size is $(n - k)$ bits
The code can correct up to (t) errors in a codeword, where $(2t = n - k)$.

Generator Polynomial of Reed Solomon

Code

In coding systems with block codes, valid code words consists of polynomials that are divisible by another fixed polynomial of short length. This fixed polynomial is called generator polynomial.

In Reed Solomon code, generator polynomial with factors is constructed where each root is a consecutive element in the Galois field. The polynomial is of the form -

$g(x) = (x - \alpha)\ (x - \alpha 2)\ (x - \alpha 3)\ ......(x - \alpha 2t)$ where α is a primitive element.

Encoding using Reed Solomon Code

The method of encoding in Reed Solomon code has the following steps -

The message is represented as a polynomial p(x), and then multiplied with the generator polynomial g(x).

The message vector [x1,x2,x3.....xk] is mapped to a polynomial of degree less than k such that px(αi) = xi for all i = 1,...k

The polynomial is evaluated using interpolation methods like Lagrange Interpolation.

Using this polynomial, the other points αk + 1....αn, are evaluated.

The encoded message is calculated as s(x) = p(x) * g(x). The sender sends this encoded message along with the generator polynomial g(x).

Decoding using Reed Solomon Code
At the receiving end, the following decoding procedure done -

The receiver receives the messager(x) and divides it by the generator polynomial

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Explain Android platform architecture

Android architecture is a software stack of components to support mobile device needs. Android software stack contains a Linux Kernel, collection of c/c++ libraries which are exposed through an application framework services, runtime, and application.

Following are main components of android architecture those are

Applications
Android Framework
Android Runtime
Platform Libraries
Linux Kernel

In these components, the Linux Kernel is the main component in android to provide its operating system functions to mobile and Dalvik Virtual Machine (DVM) which is responsible for running a mobile application.

Applications

The top layer of the android architecture is Applications. The native and third-party applications like contacts, email, music, gallery, clock, games, etc. whatever we will build those will be installed on this layer only.

The application layer runs within the Android run time using the classes and services made available from the application framework.

Application Framework

The Application Framework provides the classes used to create Android applications. It also provides a generic abstraction for hardware access and manages the user interface and application resources. It basically provides the services through which we can create a particular class and make that class helpful for the Application creation.

The application framework includes services like telephony service, location services, notification manager, NFC service, view system, etc. which we can use for application development as per our requirements.

Android Runtime

Android Runtime environment is an important part of Android rather than an internal part and it contains components like core libraries and the Dalvik virtual machine. The Android run time is the engine that powers our applications along with the libraries and it forms the basis for the application framework.

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Dalvik Virtual Machine (DVM) is a register-based virtual machine like Java Virtual Machine (JVM). It is specially designed and optimized for android to ensure that a device can run multiple instances efficiently. It relies on the Linux kernel for threading and low-level memory management.

The core libraries in android runtime will enable us to implement android applications using standard JAVA programming language.

Platform Libraries

The Platform Libraries includes various C/C++ core libraries and Java-based libraries such as SSL, libc, Graphics, SQLite, Webkit, Media, Surface Manger, OpenGL, etc. to provide support for Android development.

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The following are the summary details of some core android libraries available for android development.

Media library for playing and recording audio and video formats

The Surface manager library to provide a display management

SGL and OpenGL Graphics libraries for 2D and 3D graphics

SQLite is for database support and FreeType for font support

Web-Kit for web browser support and SSL for Internet security.

Linux Kernel

Linux Kernel is a bottom layer and heart of the android architecture. It manages all the drivers such as display drivers, camera drivers, Bluetooth drivers, audio drivers, memory drivers, etc. which are mainly required for the android device during the runtime.

The Linux Kernel will provide an abstraction layer between the device hardware and the remainder of the stack. It is responsible for memory management, power management, device management, resource access, etc.