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4. (a) For Internet of Things (IoT), the simplified IoT architecture consists of two parallel stacks, i.e., the Management and Compute Stack and Core IoT Functional Stack. Briefly describe the major components in each of the two stacks.

(7 Marks)

Answer : 4 (a)

Management and compute Stack

Cloud
Fog
Edge

Core IoT Functional Stack

Application & Analytic Layer	Application and Analytics Layer
Communication & Network Layer	Communications Network Layer
IoT devices Layer	Things Layer

For management and compute stack :

The edge and fog computing layers simply act as a first line of defence for filtering, analysing, and otherwise managing data endpoints. It saves cloud from be queried by each node for every event.

After the processing of edge and fog layer, the less time-sensitive data will be sent to cloud layer for historical analysis. big data analysis and long-term storage.

For Core Functional Stack :

Things Layer : Classify the sensors and actuators in the network. Determine which technology should be used to allow devices to communicate.

Communications Network Layer : Connect the devices for communication.

Access Network Sublayer : Decide the access technology depends on connection topology, network volume, communication range.

Gateways and Backhaul Sublayer : The gateway is in charge of the inter-medium communication. The smart objects are static or mobile within a limited area while the gateway is often static.

Network and transport Sublayer : Network protocols for routing and forwarding packets, which should be standard-based and scalable to accomodate large number of devices.

Transport Protocols is responsible for the end-to-end transmissions. In the network, existing protocols like TCP or UDP can be used.

IoT Network Management Sublayer : Application Protocols need to take care of data transmission between the smart objects and other systems. Multiple protocols have been leveraged or designed to solve IoT data communication problems.

Applications and Analytics Layer : Collect and interpret data from IoT system, control and improve the efficiency of the whole system.

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4.(b) Discuss the necessity to introduce Fog Computing into the simplified IoT architecture.

Answer (b) There are huge amount of data generated in an IoT system.

The data processing and analysis work is very heavy and cannot be totally handled by the Cloud, due to several reasons:

1) The available bandwidth of cloud server is not big enough for all of the IoT system data.

2) The latency requirement of some time-sensitive data is very high, cloud service cannot meet the requirement.

3) The communication link between cloud and IoT system sometimes is not reliable enough.

4) The devices themselves do not have enough compute ability to analysis all the data generated.

So Fog Computing is necessary to distribute the data management throughout the IoT system as close to the edge of the IP network as possible.

(c) Derive and establish the following relationship between Signal-to-Interference Ratio SIR_{dB} and cluster size N_c.

$$SIR_{dB} = 1.76 + 20\log_{10}(N_c)$$

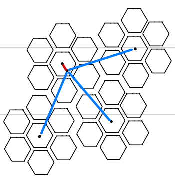
Answer (c) $SIR_{dB} = 10\lg\frac{1}{6} + 10n\lg Q = 10\lg\frac{1}{6} + 10n\lg\sqrt{3N_c} = -10\lg 6 + 5n\lg 3 + 5n\lg N_c$

When $n = 4$

$SIR_{dB} \approx 1.76 + 20\lg N_c$

(i) Consider the Simplified SIR analysis where $SIR = \frac{1}{6}Q^n$ and Q is the co-channel reuse factor and there are six co-channel interferers in the first tier. You may assume a path loss exponent of $n = 4$ in your initial evaluation. Determine the SIR_{dB} for N_c=7 and comment on your results.

Answer: (c)(i) $SIR = \frac{S}{\sum_i I_i}$



Suppose the signal power is proportional to minus exponential of n of the distance

Then $SIR = \frac{R^{-n}}{6 \cdot D^{-n}}$, where R is the radius of cell, D is the reuse distance.

Simplify: $SIR = \frac{1}{6}\left(\frac{D}{R}\right)^n$

For $N_c = 7$, $D = (i^2+j^2+ij)^{\frac{1}{2}}\sqrt{3}R = \sqrt{21}R$

$SIR_{dB} = 10\lg\frac{1}{6} + 10n\lg Q \approx -7.78 + 10\times 4\lg(\sqrt{21}) = -7.78 + 54.10 \approx 18.66$ dB

The result is pretty good performance.

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4. c. (ii) If the required minimum SNR_{dB} is to be least 20 dB, derive the corresponding value of the path loss exponent n for this case.

Answer: (ii) For this case.

$SIR_{dB} = -7.78 + 10n\lg Q$

When $N_c = 7$, $Q = \sqrt{21}$

$SIR_{dB} = -7.78 + 6.61n$

Let $SIR_{dB} > 20dB$

$n > 4.20$ The least value for exponent n is 4.20.

(iii) Using the new value of n from part (ii), determine Co-Channel interference SIR for the worst case omnidirectional as shown below.

$$SIR = \frac{1}{2(Q-1)^{-n} + 2Q^{-n} + 2(Q+1)^{-n}}$$

Answer: (iii) Given that $Q = \sqrt{21}$ $n = 4.20$

$SIR \approx 79.76$

The Co channel Interference SIR in the worse case is 79.76

(iv) Using the new value of n from part (ii), determine the SIR when using co-channel interference SIR with 120° sectoring. State and comment on your results when compared to part (iii).

Answer: (iv) $n = 4.20$

With the 120° directional antenna, the co-channel interference is:

$SIR = \frac{1}{Q^{-n} + (Q+0.7)^{-n}} \approx 385.66 \approx 25.86\,dB$

The sectoring operation increase the SIR, contain co-channel interference a lot.