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A Survey On localizing the Drone to realize Mission Critical services with 5G Open RAN Framework

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Abstract: *The Objective of the survey is to localize the drones in the mission-critical scenario while performing relief operations where there is an immense requirement for low latency and high reliability by positioning the datacenters closer to the end-user. The Super-resolution direction of arrival technique is used to localize drones i.e., helps in monitoring the journey of the drone in disaster scenarios. This paper is a survey on how a static firefighting scenario utilizing* ***Multiple Signal Classification (MUSIC) Singular Value Decomposition (SVD)*** *Algorithm that helps in estimating the direction of arrival of coherent signals.*

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I.Introduction

This paper gives an overview ofvarious generations of Wireless cellular networks and how they are different from each other concerning Radio Access Network (RAN) and one of the very important use cases of 5G i.e Ultra-reliable low latency communications(URLLC), A highly reliable and low latency dependent static firefighting scenario is considered and how drones help in this scenario for performing disaster relief operations.5G RAN helps in fulfilling this use case with the approach of a few localization techniques known as Multiple signal classification (MUSIC) with Eigen framework and Music applying SVD for coherent signals. Finally, it draws a conclusion differentiating between MUSIC and MUSIC SVD.

1.1" Role of 5G Network's: Issues, Challenges and Applications" Arun Kumar Tripathi, Akash rajak, Ajay Kumar Shrivastava

In this paper, the author explains about the evolution of wireless technologies covering from first-generation to fourth generation. Wireless networks of the first generation (1G) were designed primarily for voice communication. It could handle data transfer rates of up to 2.4kbps. Advanced Mobile Phone System (AMPS), Nordic Mobile Phone System (NMTS), Total Access Communication System (TACS), and other 1G-access technologies were the most popular. In 1G, analog signals were responsible for carrying voice. It has several shortcomings, including poor signal quality, low capacity, Insecure data transmission, and unreliable handoff.

The Second Generation (2G) of wireless networks was primarily designed for voice communication and was capable of data transfer speeds of up to 64kbps. Global Systems for Mobile Communications (GSM), Code Division Multiple Access (CDMA), and IS-95 were the most popular 2G-access technologies. Text messages, picture messages, and Multimedia Messaging Services (MMS) were all possible with 2G technology. It can also provide secure point-to-point communication, which means that the message can only be read and received by the intended recipient. 2G had several serious problems, including a slow data rate, limited cell capacity, and a higher handover time.

Second-Generation Network Expansion (2.5G) It was a development of second-generation wireless technology. It introduces the General Packet Radio Services (GPRS), a packet-based switching technique.It can also provide better communication through the use of packet switching and circuit switching techniques. It can transfer data at a rate of up to 144kbps. GPRS, Code Division Multiple Access-2000 (CDMA2000), and Enhanced Data Rate for GSM Evolution (EDGE) were the most popular 2.5G-access technologies.

In the year 2000, the third generation (3G) of wireless networks was standardized. The primary goal of 3G was to provide voice communication and high-speed data transfer of up to 2Mbps. Wideband Code Division Multiple Access (WCDMA), CDMA2000, and Universal Mobile Telecommunications Systems (UMTS) were the most popular 3G-access technologies. Specific applications include video calling, online games, email, and social media services such as Facebook and Orkut were developed to take advantage of 3G smartphone technology.

Wireless networks of the fourth generation (4G) was standardized in 2010. 4G is designed to handle data transfer speeds of up to 300Mbps while maintaining a high level of quality of service (QoS). Users of 4G can watch high-definition (HD) video online and play online games. Voice over LTE (VoLTE) is the most widely used 4G access technology (use IP packets for voice). Long Term Evolution (LTE) is currently being standardized by the 3G Partnership Project (3GPP). It provides secure mobility and reduces latency for critical applications. It also allows IoT-enabled devices to communicate efficiently. In terms of hardware and implementation, 4G is more expensive than 3G. High-end multifunctional devices that are compatible with 4G technology are required for communication.

The 5G wireless network can provide services to billions of devices with near-zero latency. In the year 2020, 5G was standardized.5G can handle data transfer speeds of up to 10Gbps. Higher speeds enable you to watch Ultra High Definition (UHD) videos online and play online games. The complications and challenges with the development of 5G includes

- High Data Rates and Increased Network Capacity with Energy Optimization
- High Data Rates, Network Capacity Expansion with Energy Optimization Full Duplex Communication Channel
- Environmentally Friendly
- Low Latency and High Reliability
- Network Performance Optimization
- High Mobility and Handover

The Applications of 5G include Environmental Monitoring, Smart Agriculture, Smart metering with 5G network, Smart Health, Internet of Vehicles, Smart Home. All the Applications mentioned above needs very low latency and ultra-high reliability which can be attained through 5G.

1.2 "Key Enablers to Deliver Latency-as-a Service in 5G Networks" Rekha M Das, Sree Lakshmi S, SeshaiahPonnekanti, Milan Paunovic

In this paper, the author explains about the key enablers which deliver latency as a service. There is a drastic change in the evolution of cellular technology in terms of Architecture, Implementation, and deployment options. And the services offered from legacy technology to contemporary technology have grown more advanced.With the advent of 5G, 3 use cases are addressed namely Enhanced Mobile Broadband (eMBB), Massive machine type communication(mMTC), and ultra-reliable low latency communication (URLLC). URLLC is one of the key enablers in 5G which supports latency-sensitive applicationsit overcomes one of the serious limitations of the previous technologies. To attain these low latency and higher reliability standards there is a need for enhancements in the Radio Access Network (RAN). As the traditional RAN has proprietary hardware where there exists vendor lock-in and it lacks flexibility. But this is not with 5G RAN which is known as "Open RAN" as the name suggests it has Open capabilities. It uses hardware from one vendor and software from the other vendor. It does not have any kind of vendor lock-in and it overcomes the limitation of traditional RAN. An observation can be made that Open RAN brings more competition among vendors. so obviously decreases the price and improves the performance of the network. It is all possible by making optimum use of virtualized edge infrastructure through Network Function Virtualization (NFV) and Software-Defined Networking (SDN). Both technologies go hand in hand and make 5G service-based Architecture where all the network functions are virtualized and they run on virtual machines or containers. one function can run on one or more virtual machines. And to route, all the functions SDN plays a crucial role.

Here are the key enablers to Realise low latency

- Mobile Edge Computing (MEC)
- Open RAN
- Ultra-reliable low latency communication (URLLC)

The very first one i.e., MEC it works with NFV where NFV splits the hardware and software and makes the functions to be virtualized and these functions run on virtual machines or containers and functions run as per the service opted by the customer. Mobile edge computing (MEC) has cloud computing capabilities at the edge of the network which can be placed very close to the end-user. Thereby decreasing the latency and can have faithful communication.

The next one is Open RAN. Here we can map between Open RAN and legacy RAN when we do so we can observe that the traditional RAN contains Remote Radio Head (RRH) and Base Band Unit (BBU). These are collocated at the cell site and they lack the flexibility as they have vendor lock-in. With the advent of Open RAN, the vendor lock-in can be resolved.

5G RAN consists of gNodeBs connected to the core network (CN). In open RAN the gNodeB has three functional modules namely

- Radio Unit (RU)
- Distributed Unit (DU) and
- Centralized Unit (CU)

Here the Radio Units are the antennas that are closer to the end-user. Distributed Units are like edge data centers that can be placed at the campus, enterprise, etc. Centralized Units are the Bigger Datacentres. And we can have more split options depending upon the density of users, locality, and service requirements. However, the Edge data center is the one that helps in maintaining latency. For example, when Biometric Attendance is considered sometimes, it shows a lot of issues concerning the server. Then it displays the issue like could not connect to the server at this moment as the server is somewhere away from the host this happens. When we consider having the edge data center where the fingerprints will be recorded in the edge data center located in the campus or enterprise itself then there won't be this kind of issue without any latency issue the authentication can be completed.

The Third one is Ultra-reliable low latency communication, The stringent latency and reliability requirements(URLLC) can be attained through 5G New Radio (NR). Certain features enable low latency like

- Fast or Hybrid ARQ is moved to PHY: This helps swift retransmissions
- Grant free access: No prior handshakes are required for resource allocation
- Scalable NR slots: Mini slots have 14 symbols; these mini-slots can be accommodated in one slot.
- Scalable NR Numerology: Scalable Numerologies are supported by 5G NR to serve a wide range of the spectrum.

To provide latency as service certain steps are followed. Network slicing is the one that creates a logical network and customizes the network according to the user service requirements by running appropriate Network Functions (NFs). The lifecycle of Network slicing is depicted in the figure below.

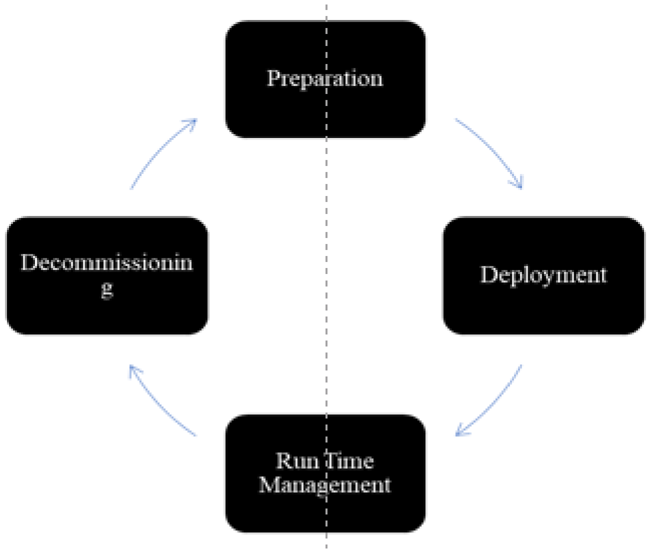

Fig 2.2 Lifecycle of Network slicing

- **Preparation**: Network Service Descriptor (NSD) explains the network service with required VNFs which has to be executed by the NFV orchestrator.
- **Deployment:** In this stage, the slice is assigned to users thereby performing activation and instantiation.
- **Run Time Management**: Slices are monitored in real-time to verify whether the VNFs are meeting the service requirements of the customer.
- **Decommissioning:** This is the final stage where the deactivation or decommissioning of the slice takes place.

A conclusion can be drawn from the above concept that the 5G RAN and the candidate software technologies help in attaining ultralow latency and high reliability.

1.3 "Open RAN Deployment Using Advanced Radio Link Manager Framework to Support Mission Critical Services in 5G" SreeLekshmi S, SeshaiahPonnekanti

In this paper, the author explainsan advanced Radio link manager Framework to support Mission Critical Services. Firstly, Mission Critical services in short MC services are the one that requires low latency and ultra-high reliability to meet this kind of requirements an enhanced RAN is needed which is obtained with 5G. As one of the use cases of 5G which is ultra-reliable low latency communication.It will take care of mission-critical services like Telemedicine, Autonomous car, etc. There are lots of radio links like users to the network, robots to network, Vehicles to network.To allocate radio resources to these kinds of radio links an advanced and efficient Radio link manager is necessary which is obtained by Machine learning.

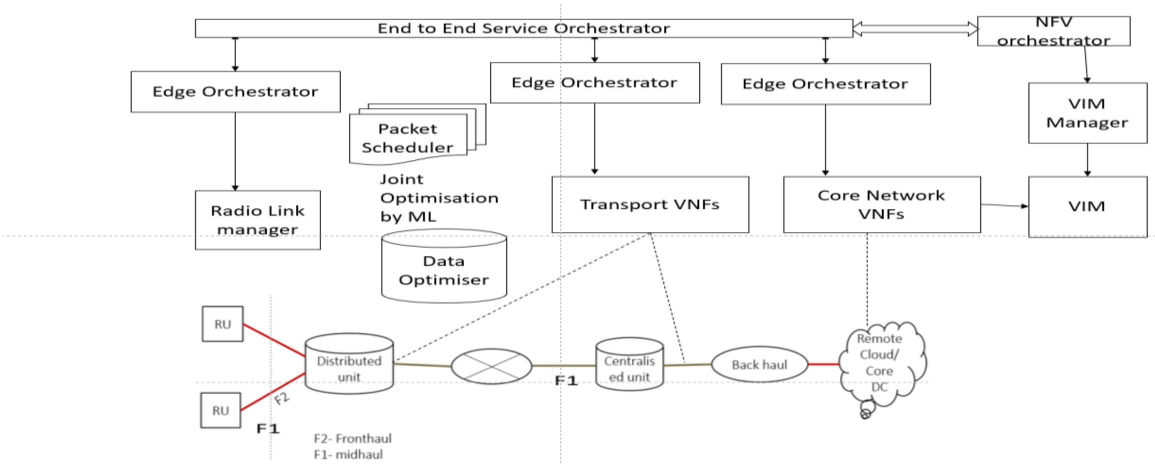

Fig 1.3 Architecture Framework for Advanced RLM

Network function virtualization replaces dedicated network appliances by running virtual network functions on top of general-purpose hardware. NFV-MANO is made up of three main functional blocks.

NFV Orchestrator: NFV Orchestration involves Monitoring and management of NFV. It has to perform functions like allocation of new VNFs, Lifecycle management of the Network slice, and provisioning of the radio resources.

VNF Manager: It Coordinates and life cycle Management of VNFs

Virtualised Infrastructure Manager (VIM): It is Responsible for the management of NFVI. The VMs are created, maintained, and terminated from the resources allocated by VIM. It contains a record of different kinds of resources allocated to VMs

5G Packet scheduling strategy for MC services helps in attaining stringent requirements like reliability, latency, and availability of the network. Certain changes have to be done with the 5G scheduler which includes

- RAN slicing
- Compact Radio Resource Management (RRM)
- Distributing of Network Functions (NFs)

RAN slicing is the allocation of resources in slices as per user requirement It provides Radio resources in the form of Network Functions (NFs). For example, the ultra-reliable low latency service requires one kind of slice (i.e., Radio resources) while the IoT-based applications require a different kind of slice. It means depending upon the latency, the number of users to be served the slicing varies.

The second change is compact RRM. As there exist different kinds of radio links in the network like network to drone, network to vehicles, humans to network. The sensors in the IoT network are less power-consuming so they are energy efficient, and they need a low data rate. Hence, we can conclude that radio resource management varies for IoT networks in comparison with the cellular network.

The third one is Distributing Network Functions (NFs) Through the use case perspective to meet certain requirements. MEC-based Open RAN enables certain VNFs functions to be executed at the edge. As the network is partitioned logically into slices so the slice aware RAN can take control of control plane (CP) functions like policy control Function (PCF) or Mobility management function (MME) at the edge or near to the user to reduce latency and provide ultra-high reliability.

Machine learning is one of the key technologies for advanced radio link manager

As we know when there is a huge number of devices in the network then there exists a lot of data. This entire data once received has to be processed in a real-life scenario for processing the voluminous data there is a need for data analytics and data optimization. one such data analysis method is Machine learning which enables machines to make optimum use of data available and make predictive and proactive decisions in real-time.

As we know wireless environment does not have a constant behavior all the time so machine learning plays a very important role in learning from the data available and finding out the different kinds of variations that are occurring and predicting the results and thereafter taking the decision or perform certain actions so that the user equipment (UEs)can predict the traffic and resource can be allocated dynamically.

As the 5G handles latency-sensitive applications so it is very important to be proactive than reactive. The radio resource management algorithm is generated by the data collected through RAN and the algorithm changed dynamically over time depending upon the traffic scenarios. There are various kinds of learnings to take predict or take decisions proactively from the data which has been collected.

Supervised Learning: This is a technique where the future is predicted depending upon present input and output data

Unsupervised learning: It is a technique that concludes the input values without prior knowledge of the output
Reinforcement Learning: This is a technique that makes continuous trials and takes decisions dynamically. As we know in 5G different kinds of a large number of devices will be operating in different bandwidths so it is challenging to design the ML-based RRM Algorithm. Hence it leads to a scalable flexible and dynamic packet scheduler that makes decisions depending upon the varying traffic conditions. To provide various learning conditions for RRM. A database should assist Radio management about the record of no of call drops, Automatic Repeat Request (ARQ), Bit error rate (BER), Number of users at the location. There are some areas where machine learning plays a very important role in RRM

- Link Adaptation
- Location
- Resource Block
- Beamforming for Massive MIMO
- Automatic Repeat Request (ARQ)

Link Adaptation: Block error rate is one of the performance metrics which indicates the reliability of the communication link so link adaptation is based on that metric.
Location: There are certain locations where frequent call drops take place. Such kind of location information can be gained by the reference signal probing technique through which some of the fundamental parameters can be gained.
Resource Block (RB): Through online learning, the resource block can be allocated and can be used by priority of the service
Beamforming for Massive MIMO: The signal strength is enhanced in the desired direction by the beamforming technique. Adaptive and intelligent beamforming can be enabled through ML and with the advent of MIMO the interference can be reduced thereby the capacity and the performance can be enhanced.
Automatic Repeat Request (ARQs): Based upon the acknowledgments and time outs the ARQ error control mechanism retransmits the data packets. With the ML techniques, the probability of success or failure rate can be known which enhances the reliability.

1.4 "Performance Evaluation of Direction of Arrival Estimation Using MATLAB" -Sai Suhas

In this paper author explains the necessity of Direction of Arrival estimation (DOA) as it has a wide range of applications in the domain of engineering which includes wireless communications, tracking of objects, and performing rescue operations. The DOA estimation is a part of array processing that concentrates on the number of electromagnetic waves impinging on arrays.Instead of making use of a single antenna system, it is better to use an array antenna system that gives a better DOA estimation resolution.

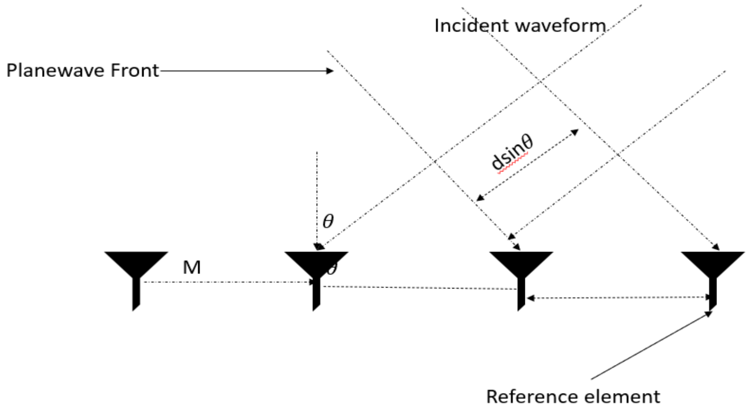

Fig 1.4 Uniformly spaced Linear Array Antenna

Here M element uniformly spaced linear array is considered the elements are equally spaced and they are separated with a distance d.
The signal is considered to be the complex sinusoidal signal which holds the form as

$$s_1(t)=e^{j2\pi f_0 t} \quad \ldots\ldots(1)$$

And the signal received by the second element will be a delayed version of the signal received by the first element so considering some delay as 'τ' we get the equation as

$$s_2(t)=s_1(t-\tau)$$
$$=e^{j2\pi f_0 t}.\ e^{-j2\pi f_{0\tau}} \quad \ldots\ldots(2)$$

Delay time τ is given by

$$\tau = \frac{dsin\theta}{c}$$

$$= \frac{dsin\theta}{f_0\lambda_0}$$

On substituting Eqn 3 in Eqn 2 we get

$s_2(t) = e^{j2\pi f_\theta t} . e^{-j2\pi f_0 \frac{dsin\theta}{f_0\lambda_0}}$

$= e^{j2\pi f_\theta t} .e^{-j\phi}$ ……………………………………...(3)

Where,

$$\phi = 2\pi \frac{dsin\theta}{\lambda_0}$$

Therefore

$s_2(t)$=$s_1(t)e^{-j\phi}$ …………………………………... (4)

Total signals received by array antenna elements is given by

$X_1(t)$=S(t)+$n_1(t)$

$X_2(t) = S(t-\tau) + n_2(t)$ … … … … … … … … … … … ...(5)

In vector form, it can be expressed as

$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ \vdots \\ x_m(t) \end{bmatrix} = s(t)\begin{bmatrix} 1 \\ e^{-j\phi} \\ e^{-j2\phi} \\ \vdots \\ e^{-j(m-1)\phi} \end{bmatrix} + \begin{bmatrix} n_1(t) \\ n_{2(t)} \\ \vdots \\ n_{m(t)} \end{bmatrix} \text{… … … … … ..(6)}$$

x(t)=$\sum_{i=1}^{M} a(\phi_i)s_i(t) + n(t)$ … … … ….…………………(8)

In matrix form, eq 8 can be expressed as

X=AS+N………………………………………………(9)

The covariance matrix D for array output D is given as

$D_x = E[XX^H]$…………………………………………(10)

Where X=AS+N,$X^H$is the conjugate transpose matrix X and N is the noise vector and A is the response function of the array element and if the white Gaussian noise with zero mean is added to this kind of signal then it becomes

$D_x = AD_sA^H$*RN……………………………………(11)

D_s is the signal correlation matrix and RN is the noise correlation matrix Now the Angular spectrum is computed as

$p_{music}\ (\theta)$=$\frac{1}{a^H(\theta)v_n v_n^H a(\theta)}$ … … … … … … … … … … … ….(12)

Orthogonality between a(θ) and v_n will minimize the denominator and hence will give rise to peaks in the MUSIC spectrum defined in equation 12

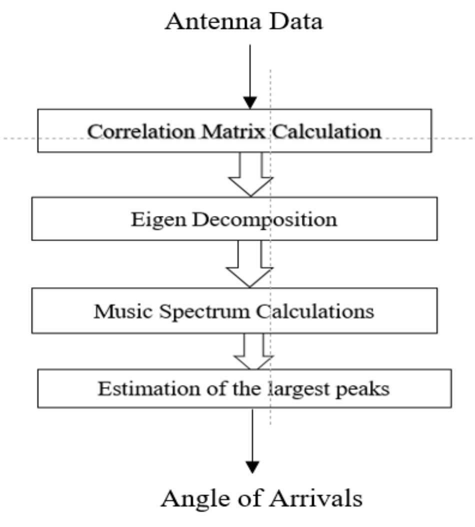

Fig 1.4.1 MUSIC implementation flow chart

1.5 Reliability Enhancement in 5G Open RAN Framework to deliver Mission Critical Services-Rekha M Das

In this work, the author explains the superior version of the Multiple signal classification Algorithm. The algorithm is enhanced by applying singular value decomposition to Multiple signal classification. It has some rich features when compared with MUSIC with eigendecompositionand also it gives higher resolution in the estimation of direction of arrival

SVD is a method to decompose a square or rectangular matrix (e.g., A, where A is a matrix of n x p), as shown

$$A_{nxp} = U_{NXN} S_{nxp} V_{pxp}^T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(13)$$

Where the U columns are the left singular vectors, where S is the diagonal matrix (the same size as A), the V^T has rows that are the right singular vectors. The SVD is an expansion of the original data, with a diagonal covariance matrix.

Calculation of SVD consists of finding the eigenvalues and eigenvectors of AA^T.and $A^T A$.Columns of V are the eigenvectors of $A^T A$ and Columns of U are the eigenvectors of AA^T.The eigenvalues from $A^T A$ or AA^T are the square roots of singular values in S. The singular values are composed of diagonal entries of the S matrix and are arranged in descending order

The following points show that SVD is superior to Eigen Value Decomposition:

The Eigenvalues and Eigenvectors which are obtained by eigendecomposition should satisfy the condition Ax*λx

- Eigenvectors are not orthonormal they form the basis for eigendecomposition
- In eigendecomposition matrix A results into A*QDQ^{-1} where D is the diagonal matrix with the eigenvalues and matrix Q with eigenvectors where,$Q^{-1}$is the inverse of Q.

Orthogonality will be lost, and the matrix becomes ill-conditioned due to multipath interference the inverse of such an ill-conditioned matrix leads to errors

- In this kind of scenario, eigendecomposition produce errors resulting in poor resolution of DOA estimation
- SVD can be applied to every matrix whereas eigendecomposition applies to only square matrices

When the array elements are smaller (typically row values) and the snapshot is larger (usually column values), then matrices are rectangular. This makes Eigen decomposition difficult, whereas the SVD approach overcomes this restriction.

The angular spectrum of the equation is computed with the equation as in the case of SVD.

$$p_{musicSVD}\,(\Theta)= \frac{1}{a^H(\Theta)*Q_n*Q_n^H*a(\Theta)}\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\ (14)$$

The noise subspace vector is denoted by Q_n. The noise subspace $Q_n$is defined by the PXP-L dimension of the right singular vectors V, while the signal subspace is defined by the PxL dimension of the right singular vectors V. The angular spectrum using modified MUSIC and SVD is shown in the equation above.

1.6 Two Decades of Array Signal Processing Research: The Parametric Approach-Hamid Krim

In this work author explains about the multipath effect or intentional jamming occurs when two coherent signals are sent in opposite directions. As a result, there is a rank deficiency in the source covariance matrix P. The signal eigenvector diverges into the noise subspace. Sofor highly correlated signals, $U_n^H a(\theta) \neq 0$ for any and MUSIC spectrum is reduced. When two coherent sources and a uniform linear array are present, there is a relatively simple way to decorrelate the signals. The way to go is to use forward-backward (FB) averaging. The steering vector remains invariant up to its scaling if the elements of a uniform linear array are complex conjugated and reversed.

Let J be an LL exchange matrix whose components are zero except for ones on the antidiagonal. Then for a ULA, it holds that

$$\mathrm{J}a^{-}(\theta) = e^{-j(l-1)\emptyset}\mathrm{a}\,(\theta)\ldots\ldots\ldots\ldots\ldots..\ (15)$$

Therefore, the backward array covariance matrix takes the form

$$R_n = JR*J = A\varphi^{-(L-1)}P\varphi^{-(L-1)}A^H + \sigma^2 I\ldots\ldots\ldots\ldots\ldots\ldots.(16)$$

Where φ is a diagonal matrix with $e^{j\emptyset k}$,k=1,……M on the diagonal. By averaging the array covariance and R_B the feedback array covariance matrix is obtained.

$$R_{FB} = \frac{1}{2}(R + JR*J)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(17)$$

$$= A\tilde{P}A^H + \sigma^2 I \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(18)$$

The new source covariance matrix $\widetilde{P} = (P + \varphi^{-(L-1)}\mathrm{P}\varphi^{-(L-1)})/2$ has full rank in this case. In the feedback version of any covariance-based algorithm, $\hat{R}$is replaced with $\widehat{R_{FB}}$. Even in the case of non-coherent scenarios, this transformation will be carried out. Forward-backward averaging is usually ineffective at storing the rank of the signal covariance matrix when there are more than two coherent sources. A practical solution to this problem is the spatial smoothing technique. This technique divides the Uniform Linear Array into several overlapping subarrays. The steering vectors of such subarrays are assumed to be identical up to different scaling, and the subarray covariance matrices can thus be averaged.

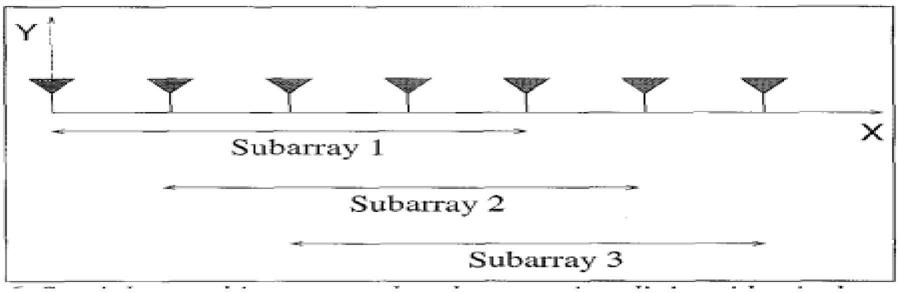

Fig 1.6 Spatial smoothing

The spatial smoothing causes a random phase modulation, which causes the signals that cause the rank deficiency to decorrelate. In terms of selection matrices F_k the expression for the smoothed matrix $\tilde{R}$. P is the number of elements in the subarrays, so k=L-p+1 is the number of subarrays. As a result, we can write the spatially smoothed covariance matrix as

$$\tilde{R} = \frac{1}{K}\sum_{k=1}^{k} F_k R F^T{}_k \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(19)$$

The rank of the covariance matrix R can be increased with probability 1 for each additional subarray in averaging until it reaches the maximum value M.Because subarrays are smaller than the original arrays, one of the potential downsides of spatial smoothing is that the array's effective aperture is reduced. Despite losing of aperture, spatial smoothing techniques mitigate all the constraints of subspace-based estimation techniques.

(1.7)Smart Network Infrastructure to Localise Drones for Supporting Mission Critical Services-S.Sreelekshmi and S.Ponnekanti

In this paper,the Author explains about aStatic firefighting instance where Flying Drones are operating in Mission-Critical Environment. It demonstrates how accurately localization can be validated by continuously monitoring the presence of drones. This is realized by DOA estimation with super-resolution algorithm MUSIC applying SVD. The instance is simulated in MATLAB to reflect the real-time environment by randomly selecting the DOA of drones and monitoring the mobile APs utilizing the super-resolution localization technique.

The following scenario is considered for the simulation:

For Normal Drone Operation to have continuous tracking in real-time: DOA estimation of drones for coherent sources applying MUSIC and MUSIC SVD.

For example, Input direction of Arrival randomly taken are $[\theta_1, \theta_2, \theta_3]$= [2030 40] and we obtain spectrum as shown below. Considering SNR=[20 20 20],phase[pi/2 pi/3 pi/4] and estimated angle is[20 30 40]for Both MUSIC and MUSIC applying SVD.An observation can be drawn Applying MUSIC SVD produces better resolution and accuracy.

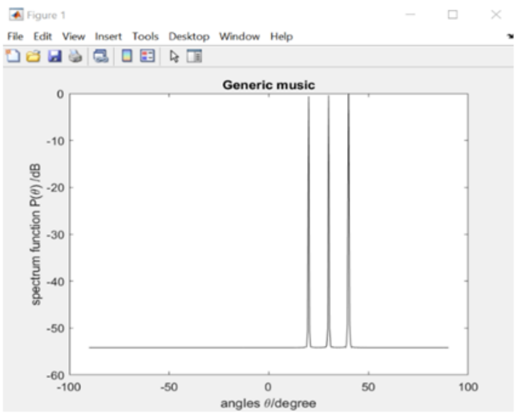

Fig 1.7 Generic MUSIC

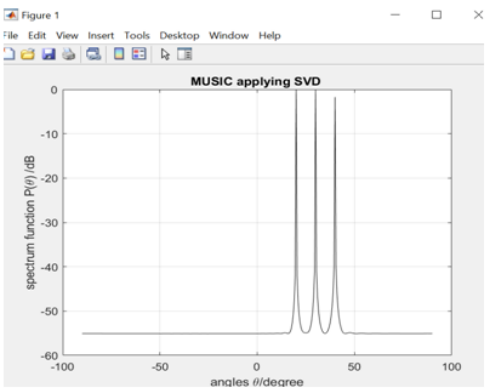

Fig 1.8 MUSIC applying SVD

Through the result analysis we can say that MUSIC SVD gives better result compared with Generic MUSIC.

II.Conclusion

Through this Detailed Survey, a conclusion can be drawn that the 5G open RAN supports the services which require low latency and ultra-high reliability due to its features which include SDN, NFV, and MEC which have cloud computing capabilities. Because of all these features accompanied with the array processing direction of arrival estimation technique called MUSIC applying SVD gives accurate results. In the future, there would be the development of more kindsof techniques for obtaining the more accurate direction of arrival estimation.

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