Efficient route-finding algorithm for Drones based on cell coverage and QoS requirements

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Motivation:

Low flight Drones are going to revolutionize future with vast number of services they can support.

- Delivery services for commercial purpose brings in whole new opportunities
- Medical kit/ food/ any emergency services
- Surveillance, Security, Monitoring services offered by Drones opens new service industry.

Unmanned Arial vehicles (UAVs) operating at low altitudes is going to multiply exponentially over the next few years over our states and cities. managing them through existing and augmented wireless infrastructure is the only manageable path.

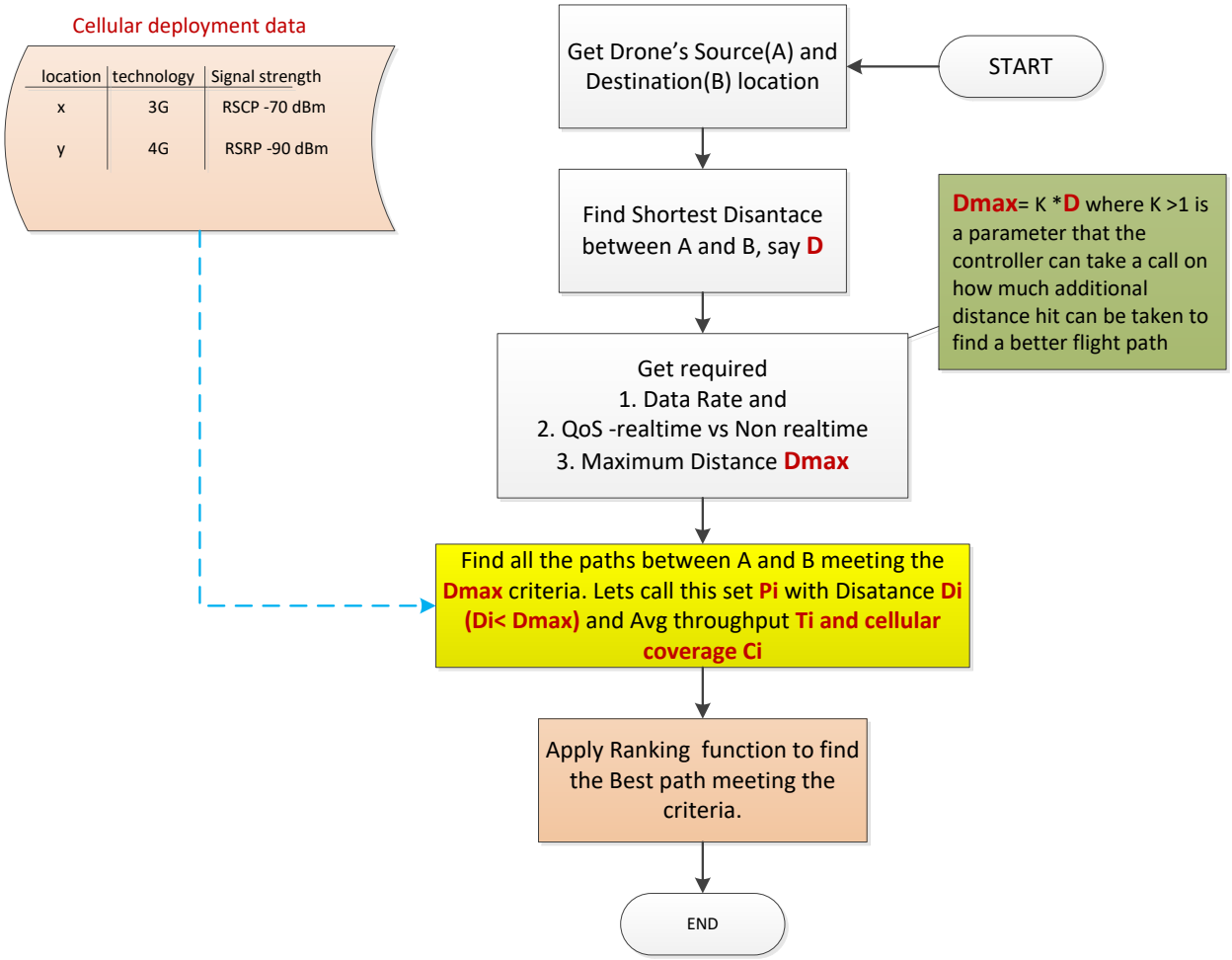
- Today many drone devices are using the cellular technology to transfer video and telemetry data back to the controller. And most of the devices supporting full HD video recording at 15fps using H.264 which generates lot of video data to be transmitted across cellular network.
- This poses a challenge as the drone moves, it encounters different RF environment causing fluctuating bandwidth which impacts the quality of the data e.g. real-time video. This is primarily because of the changing signal quality causing handovers within technology and across RATs. E.g. moving from 4G to 3G technology because of the coverage/deployment.
- Maintaining QoS is a big challenge because of cellular coverage and deployment. Coupled with this will be the need to develop a seamless handoff amongst different carriers/technologies as the UAV traverses a geographic region.

Algorithm:

- Cellular deployment data can be made available from crowdsourcing or some other source. Or this database can be generated by self-learning. This data will help to understand the
    1. RF environment i.e. signal quality (provides clues about achievable throughput). And
    2. the deployed technology 2G/3G/4G and
    3. Available service providers
- To provide reliable communication based on QoS requirement of the desired application (video/ sensor data/telemetry etc) we propose to chart out a **best flight path based on coverage and capabilities (3G/4G etc) of cells between Drone's source and destination location using the cellular deployment data. The path selection algorithm will try to**
    1. Maximize throughput and quality.

2. Minimize handovers between technologies to reduce impact to throughput.
3. Maximize cellular coverage.
4. Lower the power spent by Modem by keeping it in good coverage and less handovers. Modem spends considerable power while searching when in out of coverage or weak coverage.

- The proposed Algorithm takes input as Source and Destination locations that the Drone will travel And QoS requirements like data rate needed and nature of data- realtime vs non realtime
- Path thus calculated will be shared to control the drone/UAV or programmed onto drone before flight. While drone follows the path chosen, manual control will also be provided to overcome unexpected obstacles.



D = Shortest distance between source and destination.

C = Average received power along shortest path from BS

R = Average Throughput data rate over shortest path

P = Expected Power consumption of modem over shortest path

D_i = Distance metric. Distance between source and destination for path ***i***

C_i = Coverage Metric, Received power along shortest path from BS for path ***i***

R_i = Data throughput metric, Data rate achieved over path ***i***

P_i = Power consumption of modem over path *i*

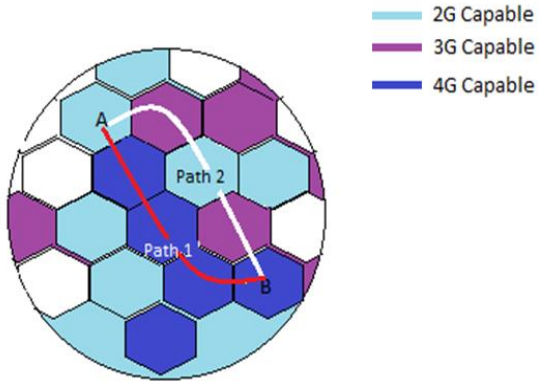
Cost function: Below is possibly one intuitive and appropriate empirical cost function we came up based on our IDF to pick up an efficient path

$$\alpha = (w_1)\frac{D}{D_i} + (w_2)\frac{C_i}{C} + (w_3)\frac{R_i}{R} + (w_4)\frac{P}{P_i}$$

For a Desired value of α, we can define weights W_i as per requirements of controller

After configuring weights to each contributor in Ranking function, all paths are ranked and a path with maximum Ranking value is ch[illegible]

	Distance Metric	Coverage Metric	Throughput Metric
Path A	D1	C1	R1
Path B	D2	C2	R2
Path C	D3	C3	R3



Results:

Example Based on Cellular deployment data from crowdsourcing at QIPL location, Hyderabad

Idea is elaborated making use of real time data around QIPL, Hyderabad location.

- In Ranking function we talked about weights. Weights are based on requirements of Drone. Lets say a surveillance drone need to transmit back video to control unit this needs to be traversed, such kind of

Drones needs to take path with good coverage. So good priority is given to weight of throughput.

- Whereas delivery drones need to transmit status messages back to control, in this case weightage will be

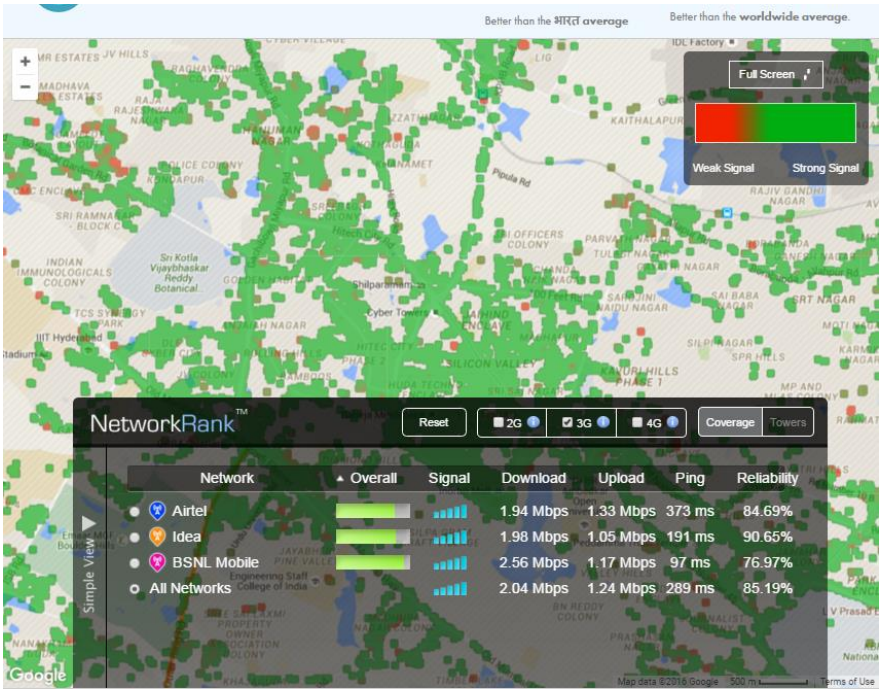
given to coverage and power consumption of modem.

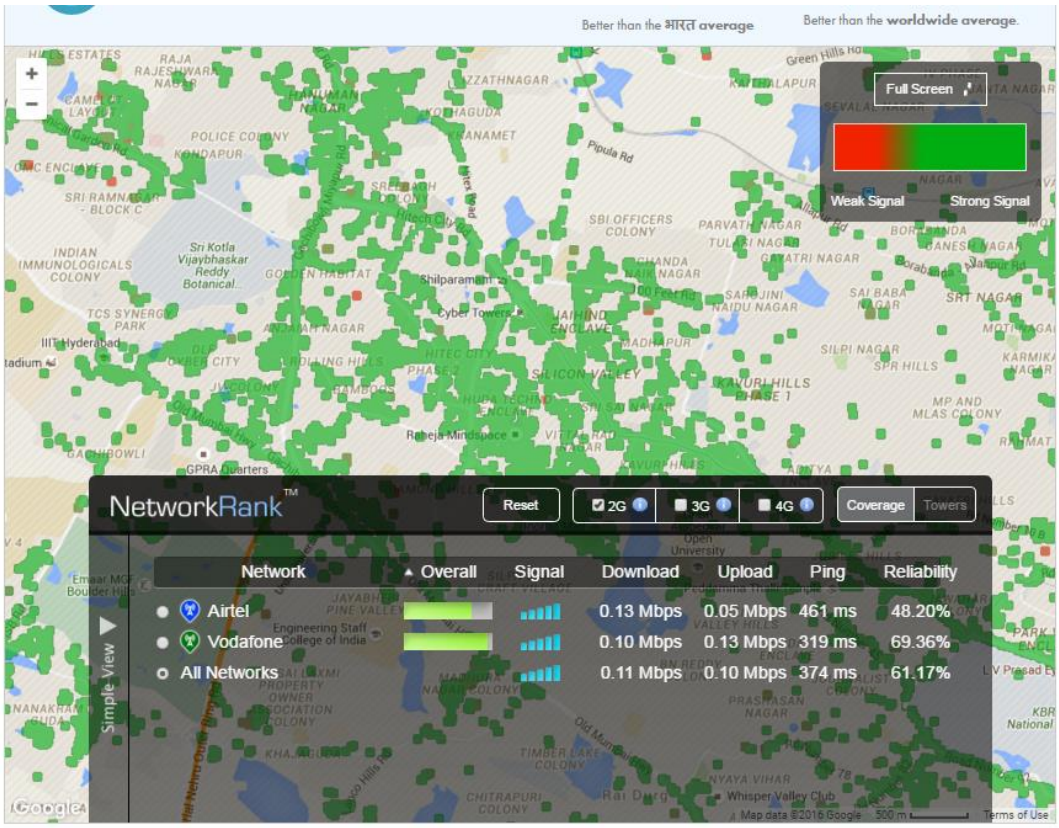
- 2G offer good coverage but low upload rates, 3G offer good coverage and moderate upload rates and

4G is least spread and offers rates suitable for video transmission.

- So path must be chosen considering above parameters we proposed.

Below are coverage, datarates, of 2G, 3G, 4G deployments. Below data clearly project how important our algorithm while choosing a path.

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Better than the worldwide average.
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Weak Signal
Strong Signal
NetworkRank™
Reset
2G
3G
4G
Coverage
Towers
Simple View
Network
Overall
Signal
Download
Upload
Ping
Reliability
Airtel
0.13 Mbps
0.05 Mbps
461 ms
48.20%
Vodafone
0.10 Mbps
0.13 Mbps
319 ms
69.36%
All Networks
0.11 Mbps
0.10 Mbps
374 ms
61.17%
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