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Boss et al.

(54) **DEPLOYMENT CRITERIA FOR UNMANNED AERIAL VEHICLES TO IMPROVE CELLULAR PHONE COMMUNICATIONS**

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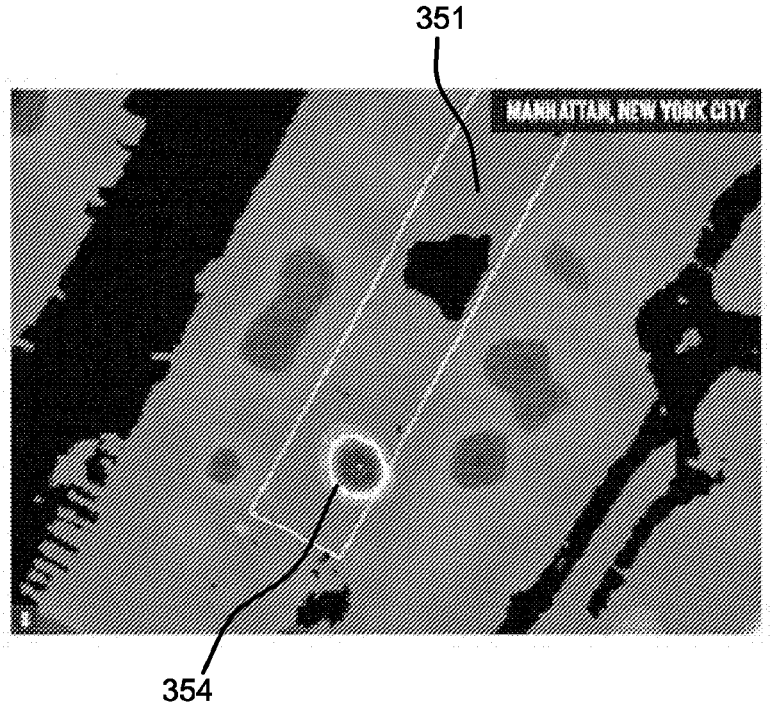
H04W 16/26	(2006.01)
H04W 24/08	(2006.01)

(52) **U.S. Cl.**

CPC ***H04B 7/18504*** (2013.01); ***H04W 16/26*** (2013.01); ***H04W 24/08*** (2013.01); ***H04W 64/006*** (2013.01); ***H04M 15/8038*** (2013.01); ***H04M 15/68*** (2013.01)

(57) **ABSTRACT**

System, method and computer program product for extending mobile device cellular carrier network coverage using unmanned aerial vehicles (UAVs) equipped with telecommunications devices to act as temporary mobile device cellular network towers. The system and method extends cellular phone coverage of a land-based cellular phone network by: receiving information for determining a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time; identifying, based on an said predicted or actual increased aggregate cellular phone usage demand for said area, whether there exists a mismatch of existing usage coverage compared with said determined increased aggregate demand for that area; determining, based on an identified mismatch, a plan for sending signals to and deploying one or more mobile cellular unmanned aerial vehicles (UAV) having telecommunications equipment configured to extend cellular phone network coverage of an existing land-based cellular phone network at the mismatched area.



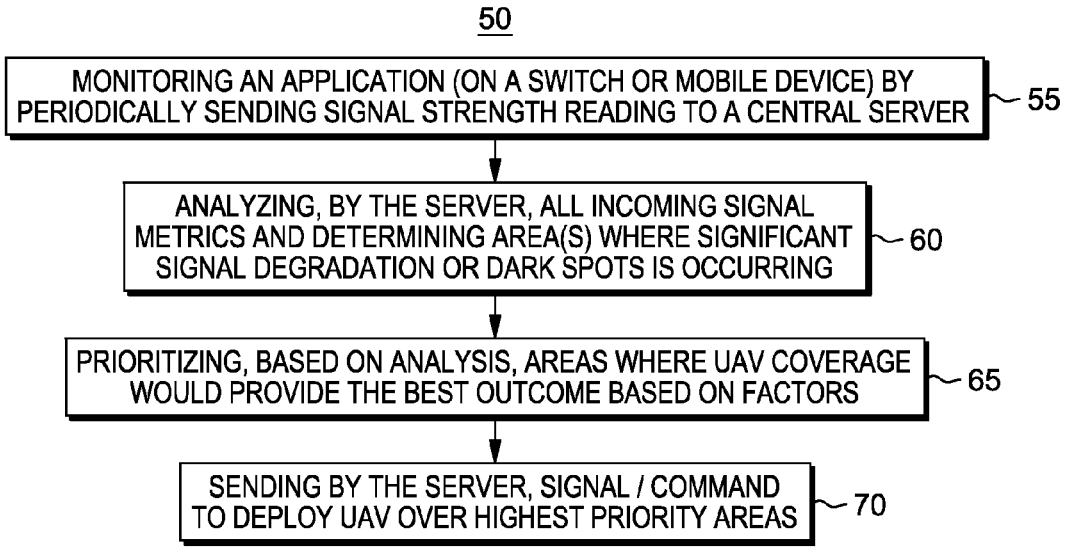

50
MONITORING AN APPLICATION (ON A SWITCH OR MOBILE DEVICE) BY PERIODICALLY SENDING SIGNAL STRENGTH READING TO A CENTRAL SERVER
55
ANALYZING, BY THE SERVER, ALL INCOMING SIGNAL METRICS AND DETERMINING AREA(S) WHERE SIGNIFICANT SIGNAL DEGRADATION OR DARK SPOTS IS OCCURRING
60
PRIORITIZING, BASED ON ANALYSIS, AREAS WHERE UAV COVERAGE WOULD PROVIDE THE BEST OUTCOME BASED ON FACTORS
65
SENDING BY THE SERVER, SIGNAL / COMMAND TO DEPLOY UAV OVER HIGHEST PRIORITY AREAS
70

FIG. 1

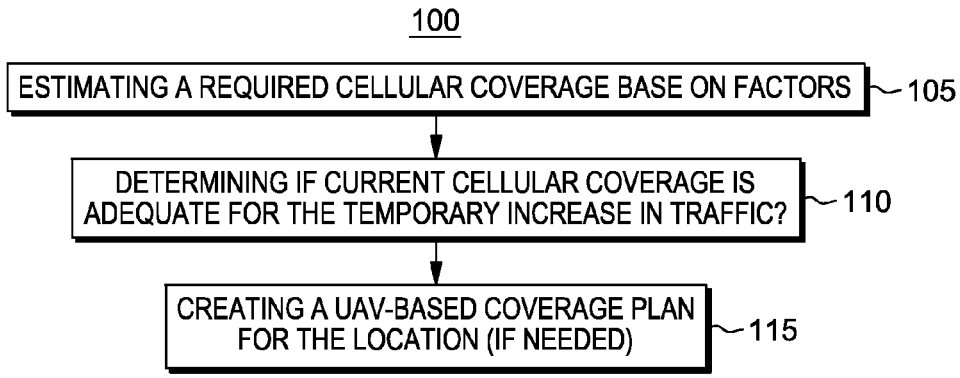

100
ESTIMATING A REQUIRED CELLULAR COVERAGE BASE ON FACTORS
105
DETERMINING IF CURRENT CELLULAR COVERAGE IS ADEQUATE FOR THE TEMPORARY INCREASE IN TRAFFIC?
110
CREATING A UAV-BASED COVERAGE PLAN FOR THE LOCATION (IF NEEDED)
115

FIG. 2

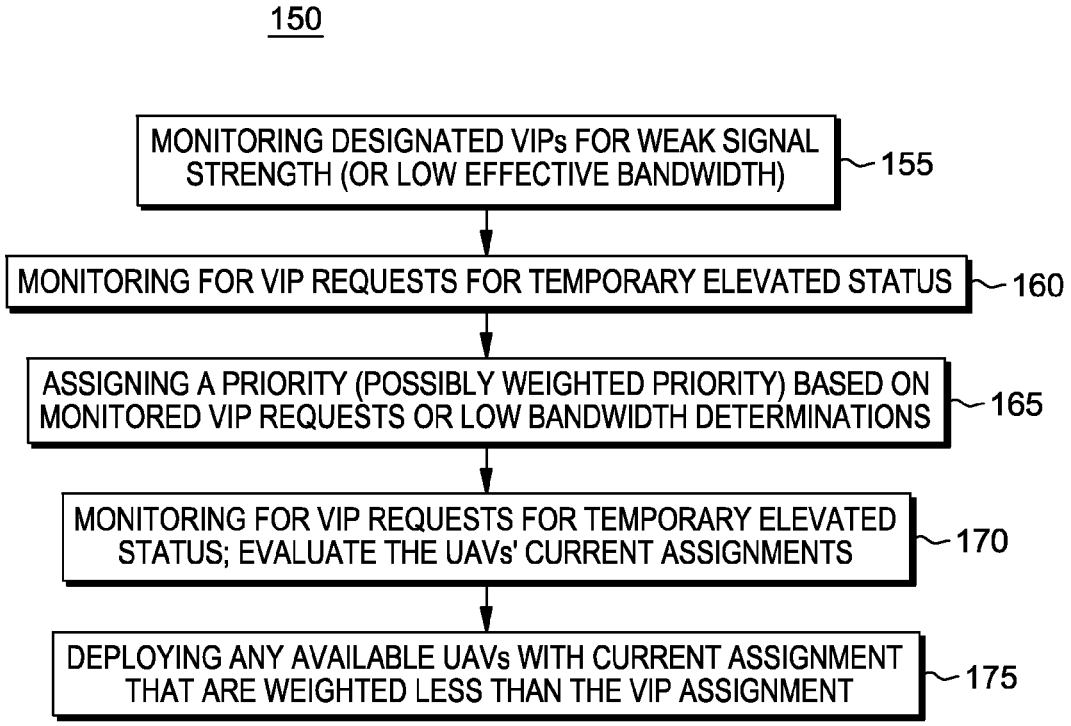

150
MONITORING DESIGNATED VIPs FOR WEAK SIGNAL STRENGTH (OR LOW EFFECTIVE BANDWIDTH)
155
MONITORING FOR VIP REQUESTS FOR TEMPORARY ELEVATED STATUS
160
ASSIGNING A PRIORITY (POSSIBLY WEIGHTED PRIORITY) BASED ON MONITORED VIP REQUESTS OR LOW BANDWIDTH DETERMINATIONS
165
MONITORING FOR VIP REQUESTS FOR TEMPORARY ELEVATED STATUS; EVALUATE THE UAVs' CURRENT ASSIGNMENTS
170
DEPLOYING ANY AVAILABLE UAVs WITH CURRENT ASSIGNMENT THAT ARE WEIGHTED LESS THAN THE VIP ASSIGNMENT
175

FIG. 3

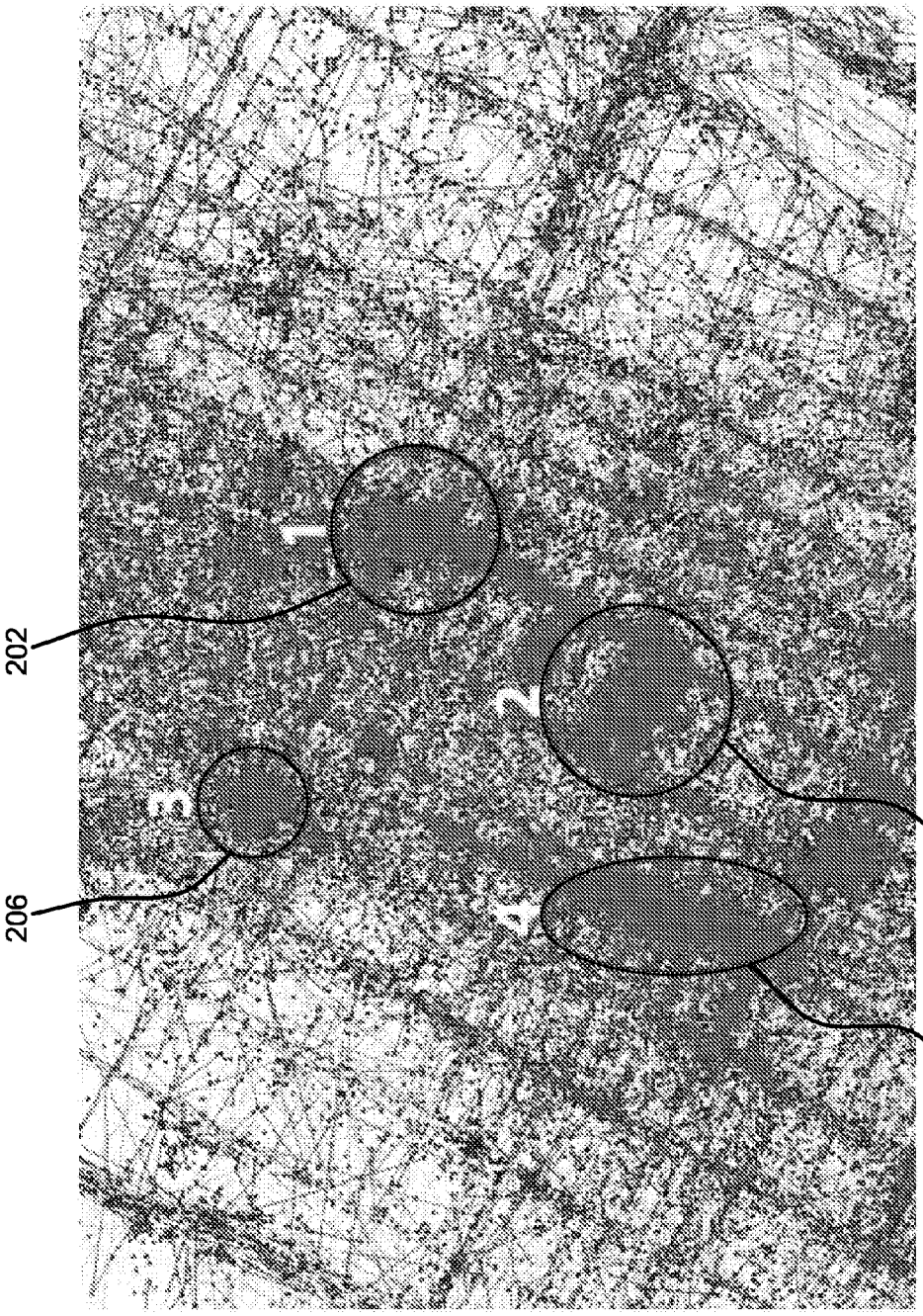


FIG. 4

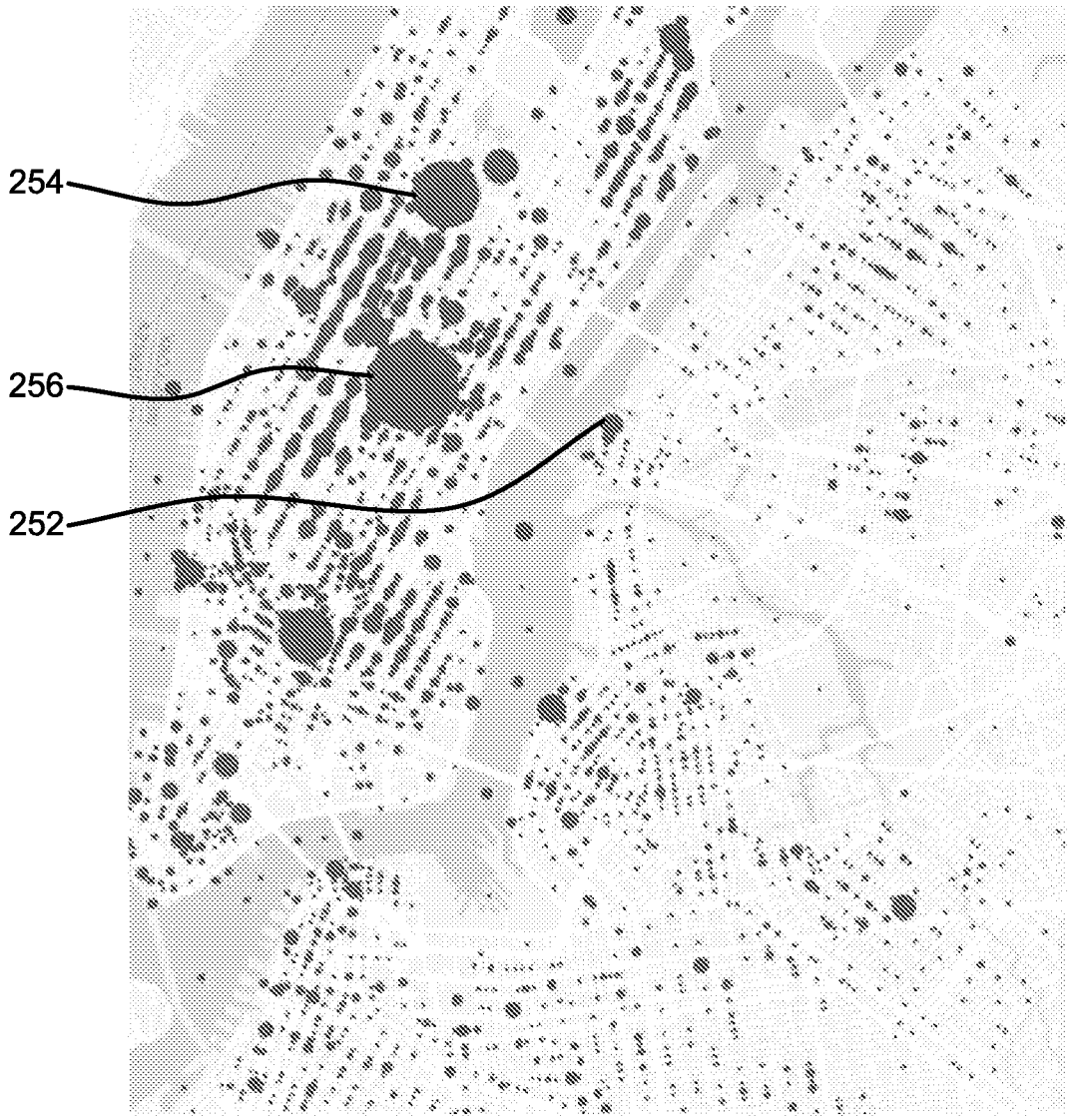


FIG. 5

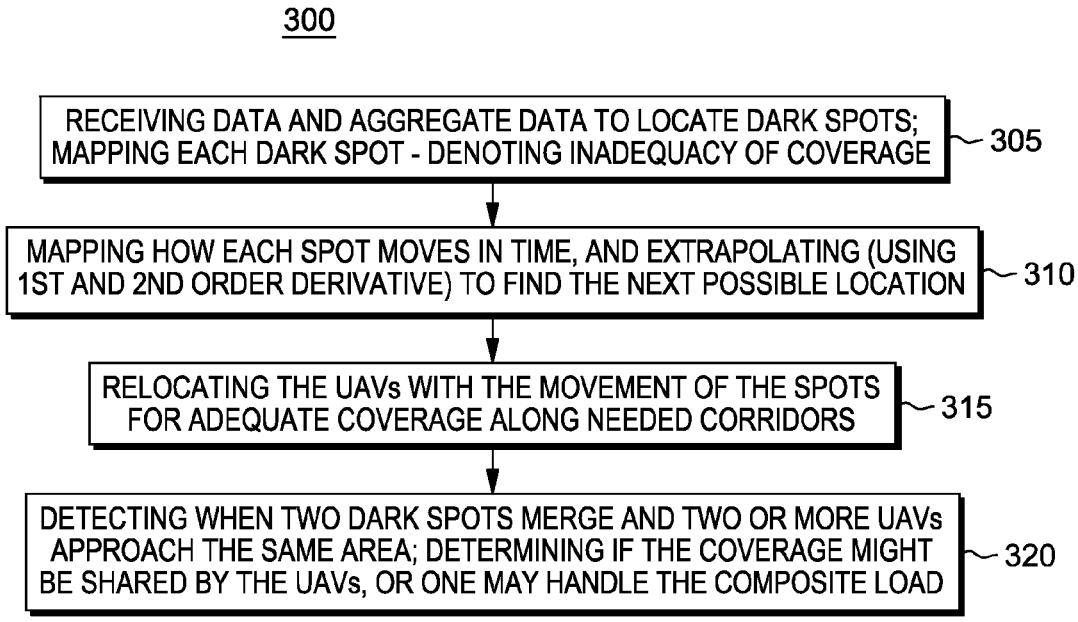

300
RECEIVING DATA AND AGGREGATE DATA TO LOCATE DARK SPOTS; MAPPING EACH DARK SPOT - DENOTING INADEQUACY OF COVERAGE
305
MAPPING HOW EACH SPOT MOVES IN TIME, AND EXTRAPOLATING (USING 1ST AND 2ND ORDER DERIVATIVE) TO FIND THE NEXT POSSIBLE LOCATION
310
RELOCATING THE UAVs WITH THE MOVEMENT OF THE SPOTS FOR ADEQUATE COVERAGE ALONG NEEDED CORRIDORS
315
DETECTING WHEN TWO DARK SPOTS MERGE AND TWO OR MORE UAVs APPROACH THE SAME AREA; DETERMINING IF THE COVERAGE MIGHT BE SHARED BY THE UAVs, OR ONE MAY HANDLE THE COMPOSITE LOAD
320

FIG. 6

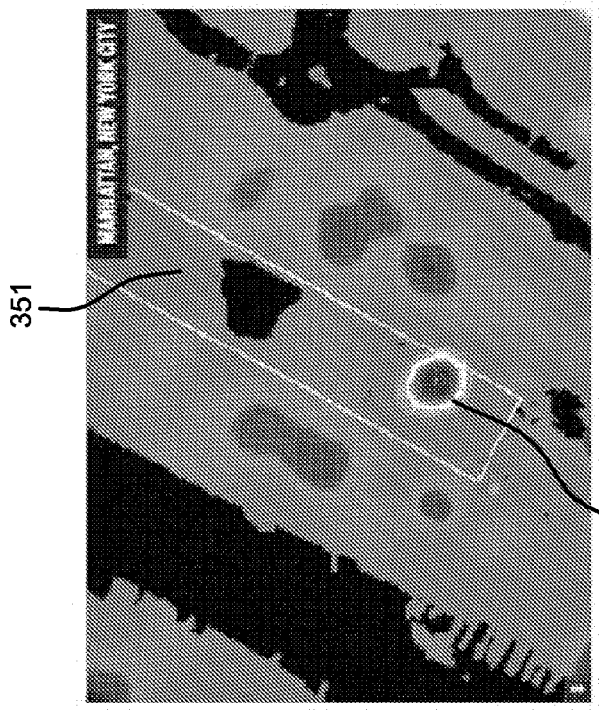


FIG. 7C

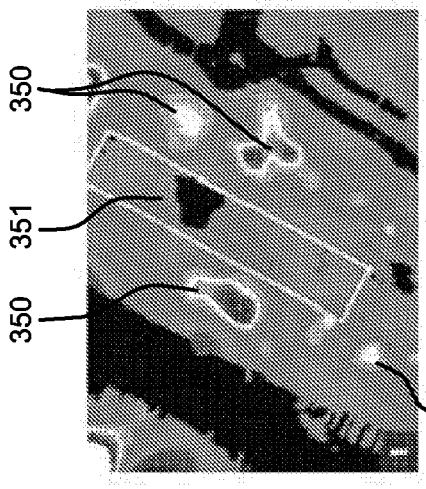


FIG. 7A

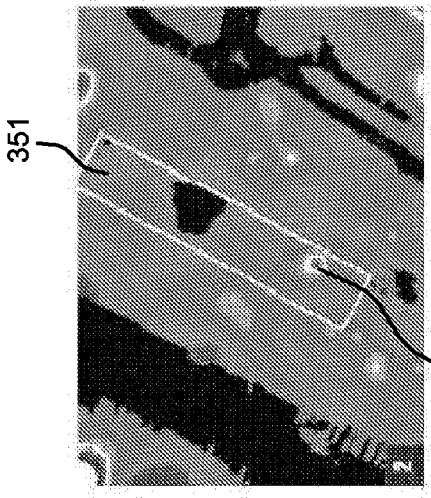


FIG. 7B

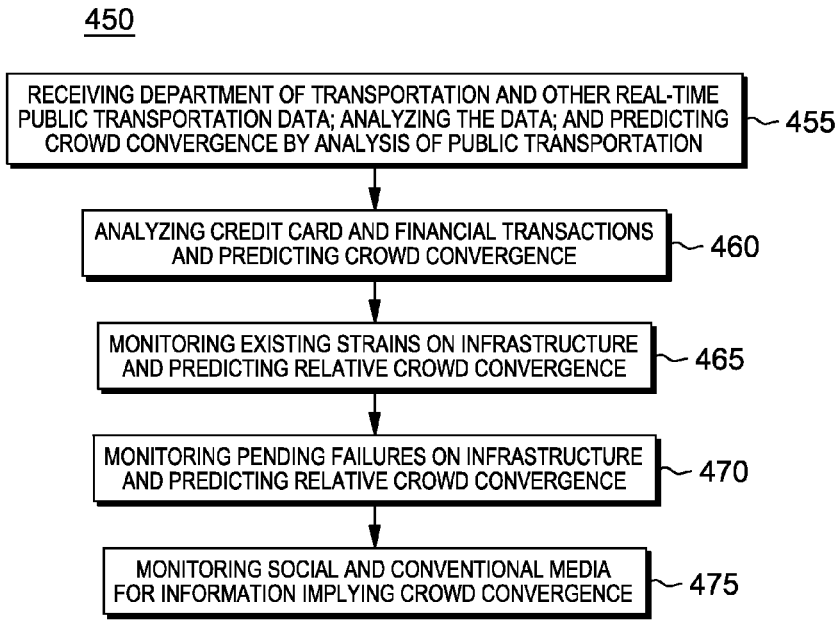

450
RECEIVING DEPARTMENT OF TRANSPORTATION AND OTHER REAL-TIME PUBLIC TRANSPORTATION DATA; ANALYZING THE DATA; AND PREDICTING CROWD CONVERGENCE BY ANALYSIS OF PUBLIC TRANSPORTATION
455
ANALYZING CREDIT CARD AND FINANCIAL TRANSACTIONS AND PREDICTING CROWD CONVERGENCE
460
MONITORING EXISTING STRAINS ON INFRASTRUCTURE AND PREDICTING RELATIVE CROWD CONVERGENCE
465
MONITORING PENDING FAILURES ON INFRASTRUCTURE AND PREDICTING RELATIVE CROWD CONVERGENCE
470
MONITORING SOCIAL AND CONVENTIONAL MEDIA FOR INFORMATION IMPLYING CROWD CONVERGENCE
475

FIG. 8

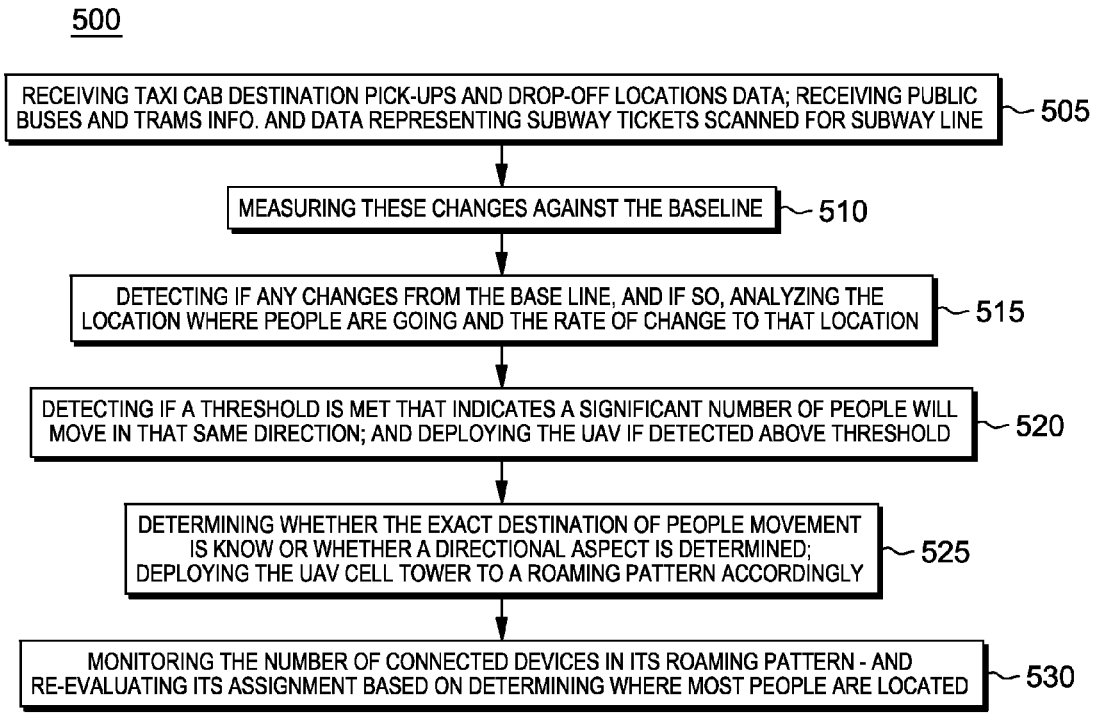

500
RECEIVING TAXI CAB DESTINATION PICK-UPS AND DROP-OFF LOCATIONS DATA; RECEIVING PUBLIC BUSES AND TRAMS INFO. AND DATA REPRESENTING SUBWAY TICKETS SCANNED FOR SUBWAY LINE
505
MEASURING THESE CHANGES AGAINST THE BASELINE
510
DETECTING IF ANY CHANGES FROM THE BASE LINE, AND IF SO, ANALYZING THE LOCATION WHERE PEOPLE ARE GOING AND THE RATE OF CHANGE TO THAT LOCATION
515
DETECTING IF A THRESHOLD IS MET THAT INDICATES A SIGNIFICANT NUMBER OF PEOPLE WILL MOVE IN THAT SAME DIRECTION; AND DEPLOYING THE UAV IF DETECTED ABOVE THRESHOLD
520
DETERMINING WHETHER THE EXACT DESTINATION OF PEOPLE MOVEMENT IS KNOW OR WHETHER A DIRECTIONAL ASPECT IS DETERMINED; DEPLOYING THE UAV CELL TOWER TO A ROAMING PATTERN ACCORDINGLY
525
MONITORING THE NUMBER OF CONNECTED DEVICES IN ITS ROAMING PATTERN - AND RE-EVALUATING ITS ASSIGNMENT BASED ON DETERMINING WHERE MOST PEOPLE ARE LOCATED
530

FIG. 9

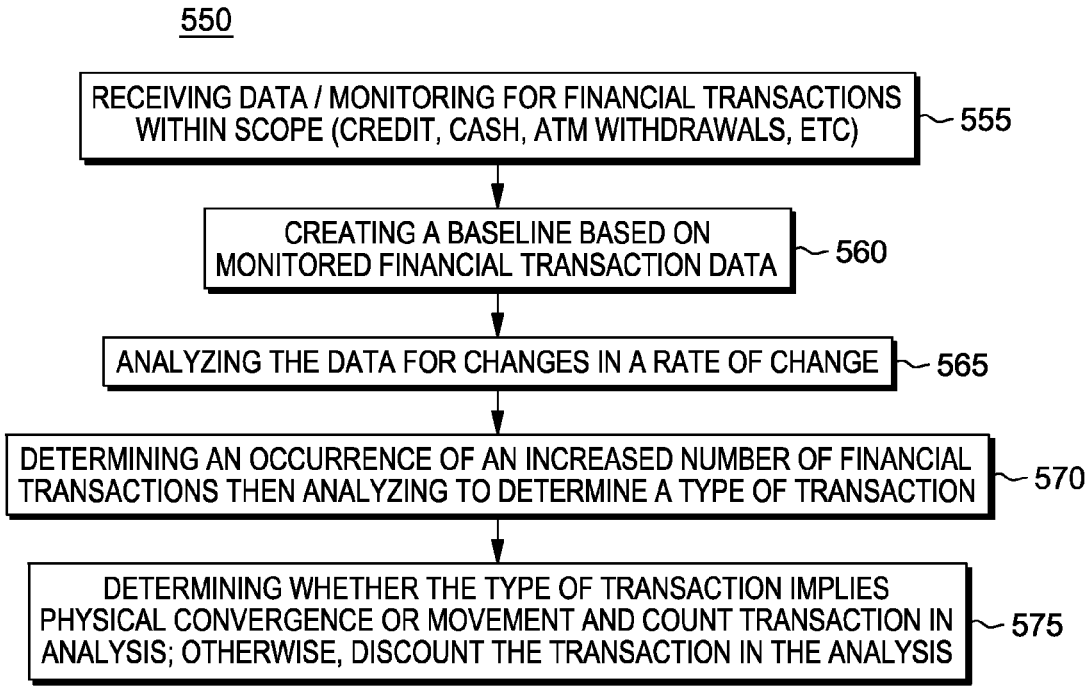

550
RECEIVING DATA / MONITORING FOR FINANCIAL TRANSACTIONS WITHIN SCOPE (CREDIT, CASH, ATM WITHDRAWALS, ETC)
555
CREATING A BASELINE BASED ON MONITORED FINANCIAL TRANSACTION DATA
560
ANALYZING THE DATA FOR CHANGES IN A RATE OF CHANGE
565
DETERMINING AN OCCURRENCE OF AN INCREASED NUMBER OF FINANCIAL TRANSACTIONS THEN ANALYZING TO DETERMINE A TYPE OF TRANSACTION
570
DETERMINING WHETHER THE TYPE OF TRANSACTION IMPLIES PHYSICAL CONVERGENCE OR MOVEMENT AND COUNT TRANSACTION IN ANALYSIS; OTHERWISE, DISCOUNT THE TRANSACTION IN THE ANALYSIS
575

FIG. 10

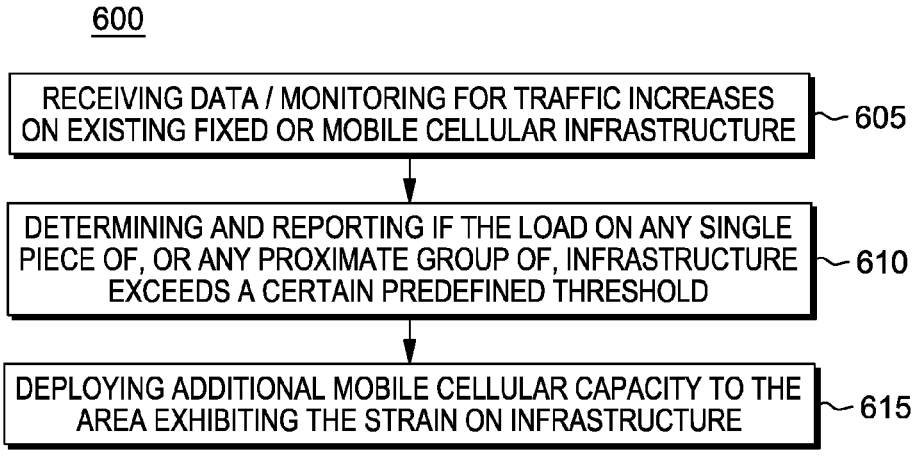

600
RECEIVING DATA / MONITORING FOR TRAFFIC INCREASES ON EXISTING FIXED OR MOBILE CELLULAR INFRASTRUCTURE
605
DETERMINING AND REPORTING IF THE LOAD ON ANY SINGLE PIECE OF, OR ANY PROXIMATE GROUP OF, INFRASTRUCTURE EXCEEDS A CERTAIN PREDEFINED THRESHOLD
610
DEPLOYING ADDITIONAL MOBILE CELLULAR CAPACITY TO THE AREA EXHIBITING THE STRAIN ON INFRASTRUCTURE
615

FIG. 11

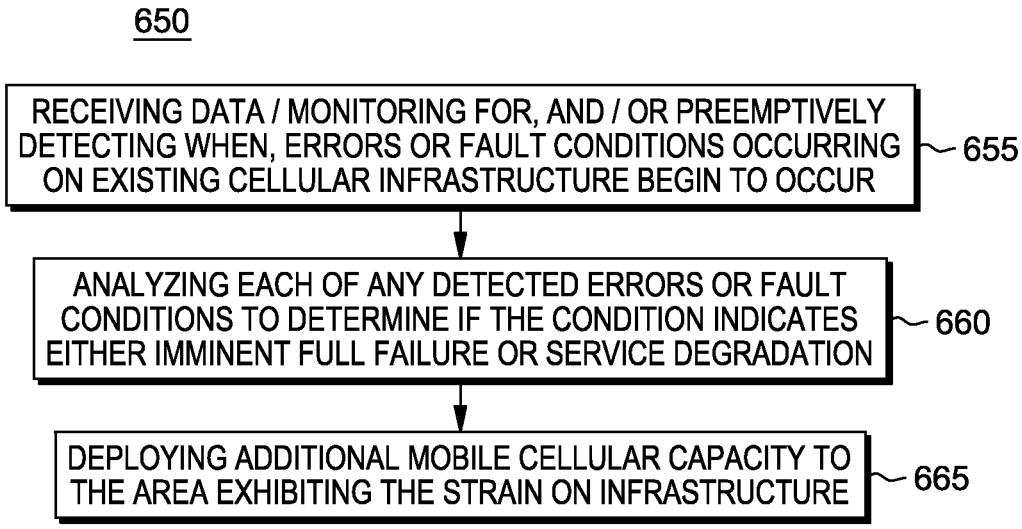

650
RECEIVING DATA / MONITORING FOR, AND / OR PREEMPTIVELY DETECTING WHEN, ERRORS OR FAULT CONDITIONS OCCURRING ON EXISTING CELLULAR INFRASTRUCTURE BEGIN TO OCCUR
655
ANALYZING EACH OF ANY DETECTED ERRORS OR FAULT CONDITIONS TO DETERMINE IF THE CONDITION INDICATES EITHER IMMINENT FULL FAILURE OR SERVICE DEGRADATION
660
DEPLOYING ADDITIONAL MOBILE CELLULAR CAPACITY TO THE AREA EXHIBITING THE STRAIN ON INFRASTRUCTURE
665

FIG. 12

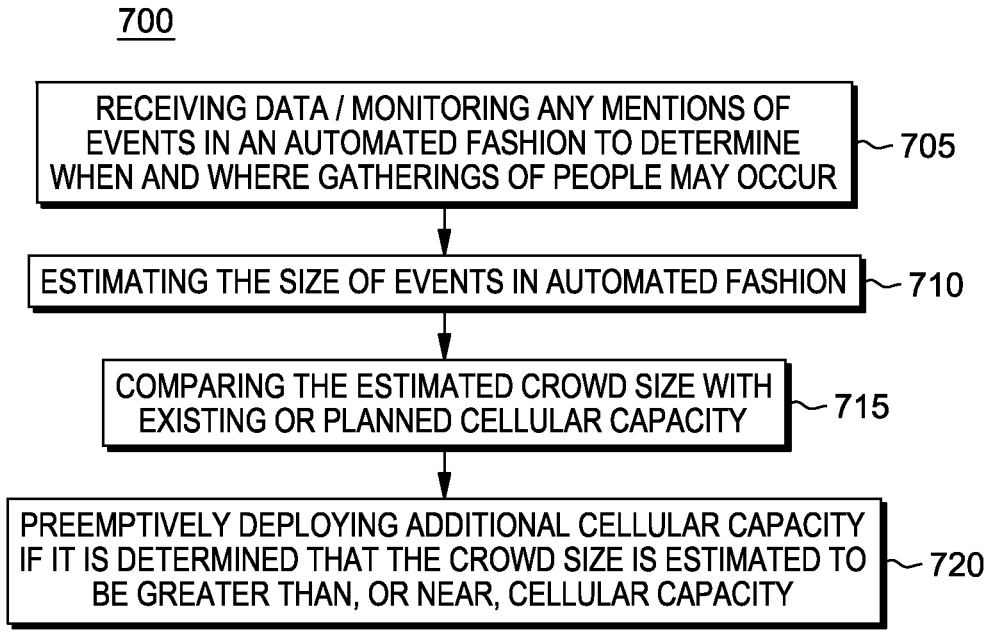

700
RECEIVING DATA / MONITORING ANY MENTIONS OF EVENTS IN AN AUTOMATED FASHION TO DETERMINE WHEN AND WHERE GATHERINGS OF PEOPLE MAY OCCUR
705
ESTIMATING THE SIZE OF EVENTS IN AUTOMATED FASHION
710
COMPARING THE ESTIMATED CROWD SIZE WITH EXISTING OR PLANNED CELLULAR CAPACITY
715
PREEMPTIVELY DEPLOYING ADDITIONAL CELLULAR CAPACITY IF IT IS DETERMINED THAT THE CROWD SIZE IS ESTIMATED TO BE GREATER THAN, OR NEAR, CELLULAR CAPACITY
720

FIG. 13

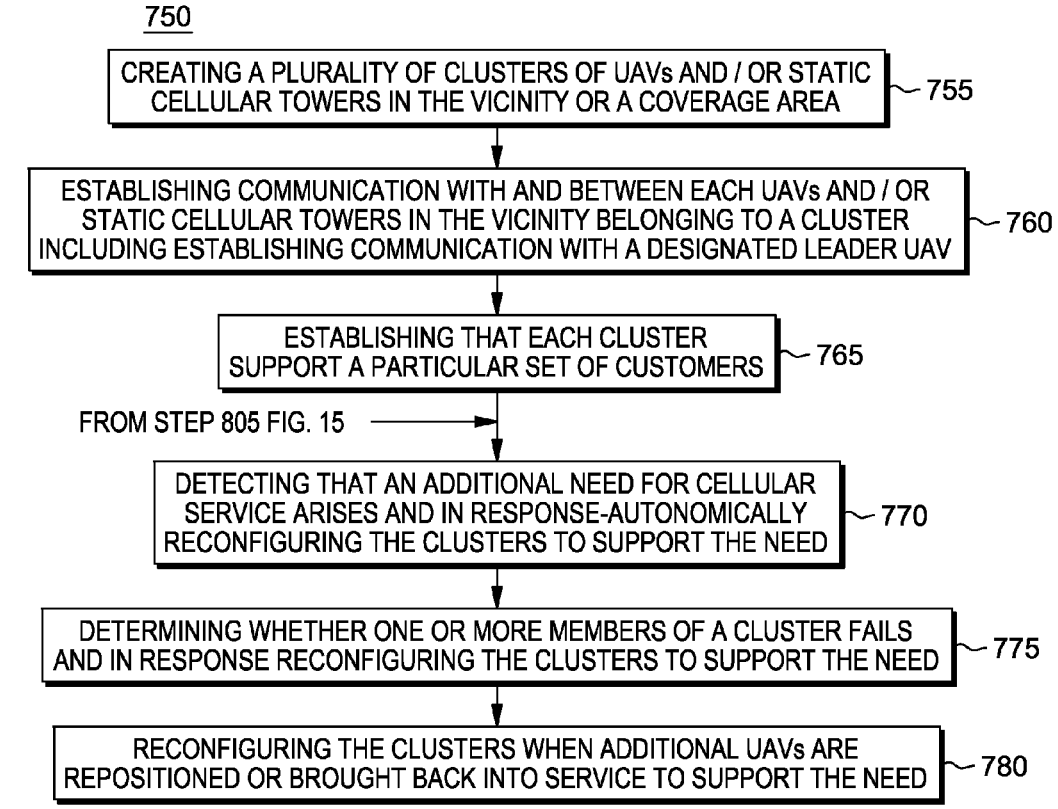


FIG. 14

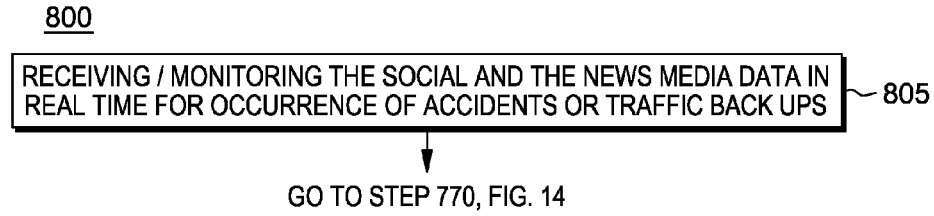


FIG. 15

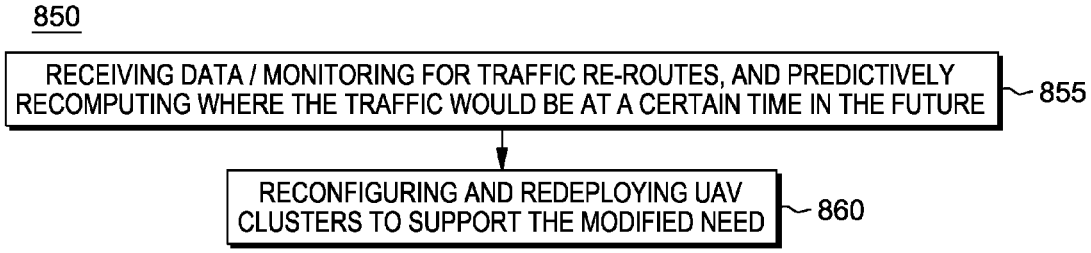


FIG. 16

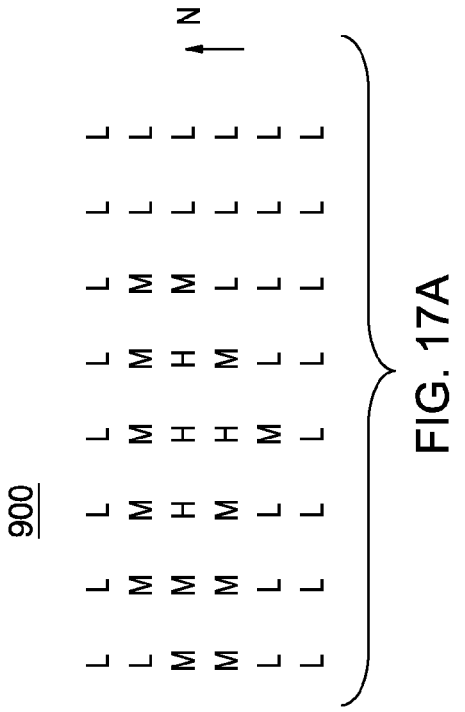


FIG. 17A

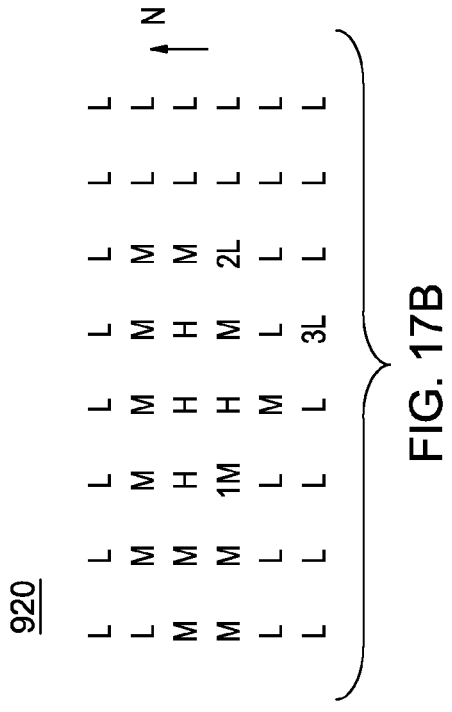


FIG. 17B

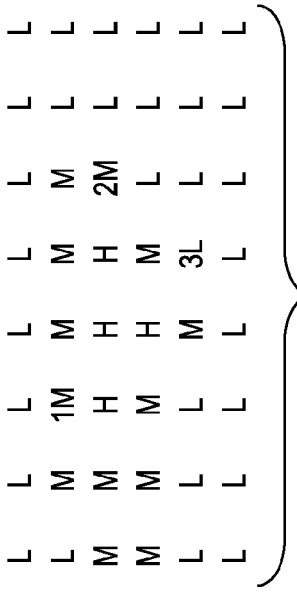


FIG. 17C

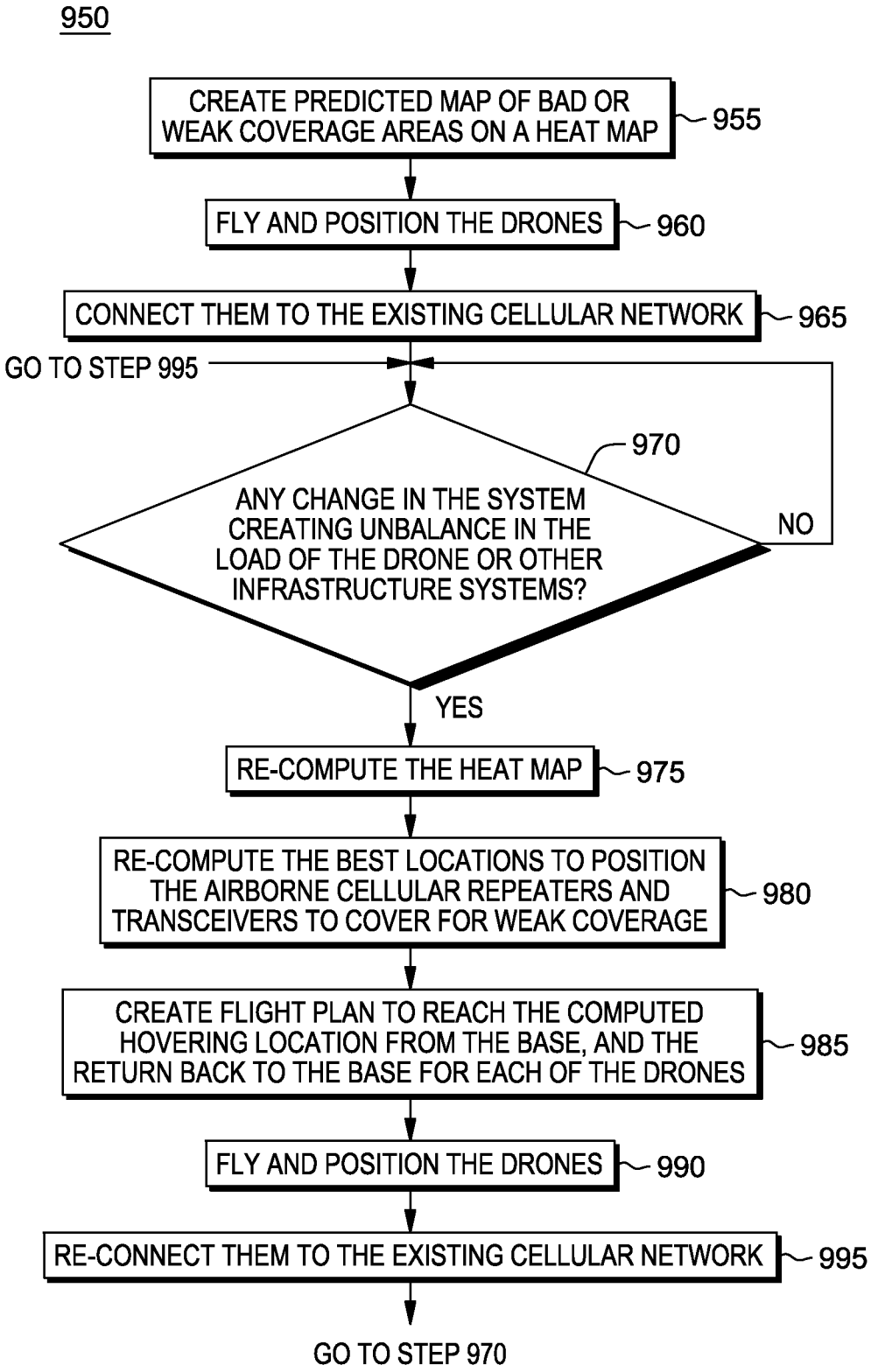

950
CREATE PREDICTED MAP OF BAD OR WEAK COVERAGE AREAS ON A HEAT MAP
955
FLY AND POSITION THE DRONES
960
CONNECT THEM TO THE EXISTING CELLULAR NETWORK
965
GO TO STEP 995
970
ANY CHANGE IN THE SYSTEM CREATING UNBALANCE IN THE LOAD OF THE DRONE OR OTHER INFRASTRUCTURE SYSTEMS?
NO
YES
RE-COMPUTE THE HEAT MAP
975
RE-COMPUTE THE BEST LOCATIONS TO POSITION THE AIRBORNE CELLULAR REPEATERS AND TRANSCEIVERS TO COVER FOR WEAK COVERAGE
980
CREATE FLIGHT PLAN TO REACH THE COMPUTED HOVERING LOCATION FROM THE BASE, AND THE RETURN BACK TO THE BASE FOR EACH OF THE DRONES
985
FLY AND POSITION THE DRONES
990
RE-CONNECT THEM TO THE EXISTING CELLULAR NETWORK
995
GO TO STEP 970

FIG. 18

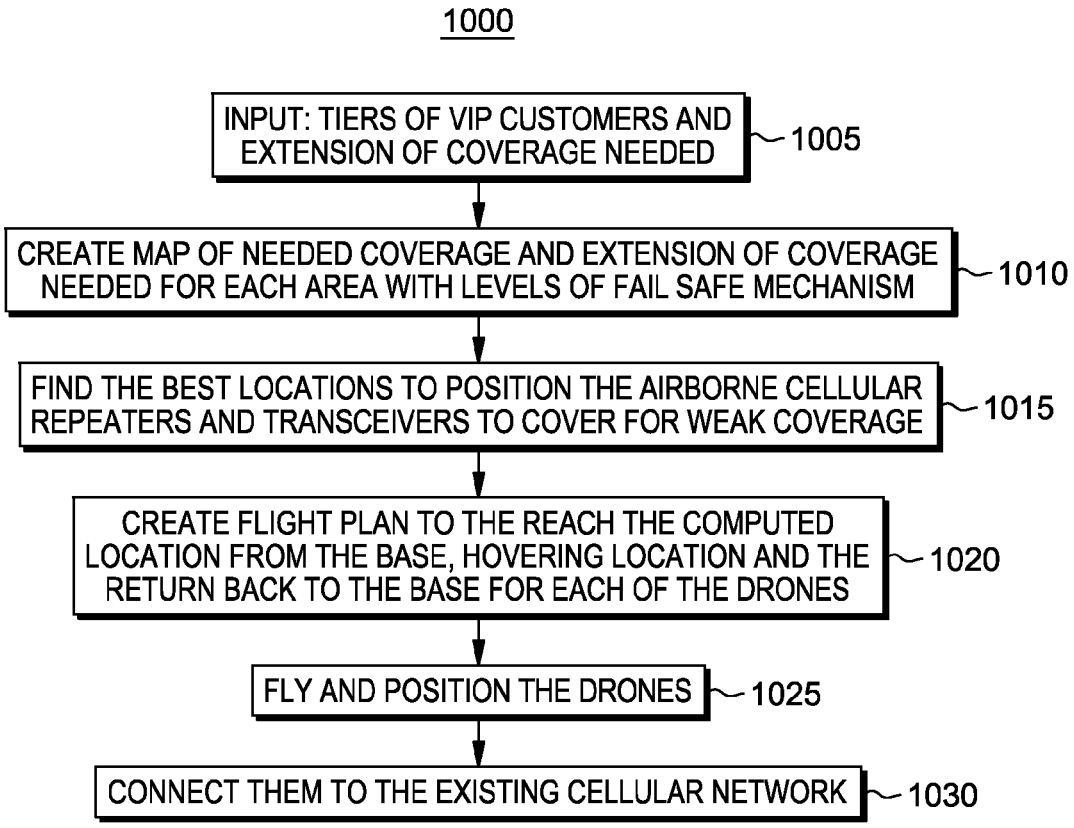

1000
INPUT: TIERS OF VIP CUSTOMERS AND EXTENSION OF COVERAGE NEEDED
1005
CREATE MAP OF NEEDED COVERAGE AND EXTENSION OF COVERAGE NEEDED FOR EACH AREA WITH LEVELS OF FAIL SAFE MECHANISM
1010
FIND THE BEST LOCATIONS TO POSITION THE AIRBORNE CELLULAR REPEATERS AND TRANSCEIVERS TO COVER FOR WEAK COVERAGE
1015
CREATE FLIGHT PLAN TO THE REACH THE COMPUTED LOCATION FROM THE BASE, HOVERING LOCATION AND THE RETURN BACK TO THE BASE FOR EACH OF THE DRONES
1020
FLY AND POSITION THE DRONES
1025
CONNECT THEM TO THE EXISTING CELLULAR NETWORK
1030

FIG. 19

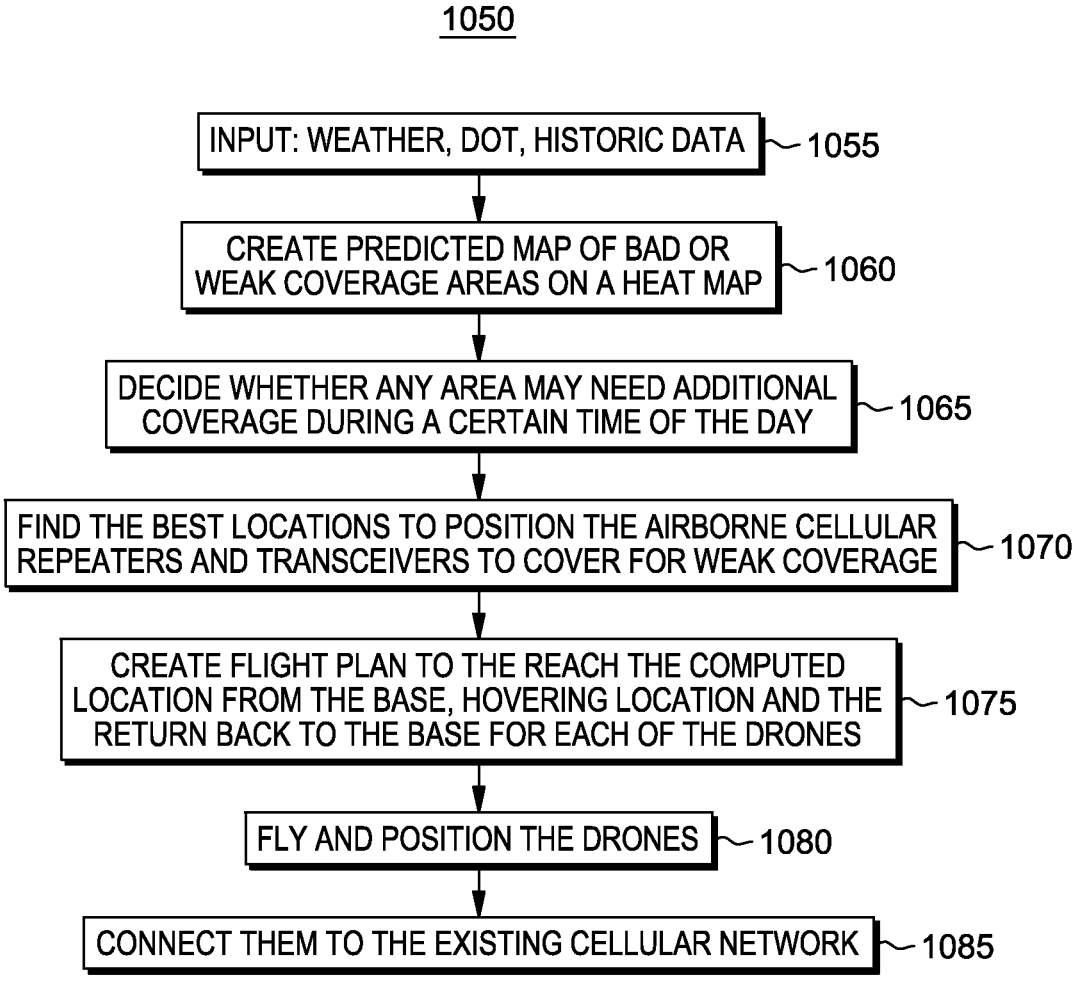

1050
INPUT: WEATHER, DOT, HISTORIC DATA
1055
CREATE PREDICTED MAP OF BAD OR WEAK COVERAGE AREAS ON A HEAT MAP
1060
DECIDE WHETHER ANY AREA MAY NEED ADDITIONAL COVERAGE DURING A CERTAIN TIME OF THE DAY
1065
FIND THE BEST LOCATIONS TO POSITION THE AIRBORNE CELLULAR REPEATERS AND TRANSCEIVERS TO COVER FOR WEAK COVERAGE
1070
CREATE FLIGHT PLAN TO THE REACH THE COMPUTED LOCATION FROM THE BASE, HOVERING LOCATION AND THE RETURN BACK TO THE BASE FOR EACH OF THE DRONES
1075
FLY AND POSITION THE DRONES
1080
CONNECT THEM TO THE EXISTING CELLULAR NETWORK
1085

FIG. 20

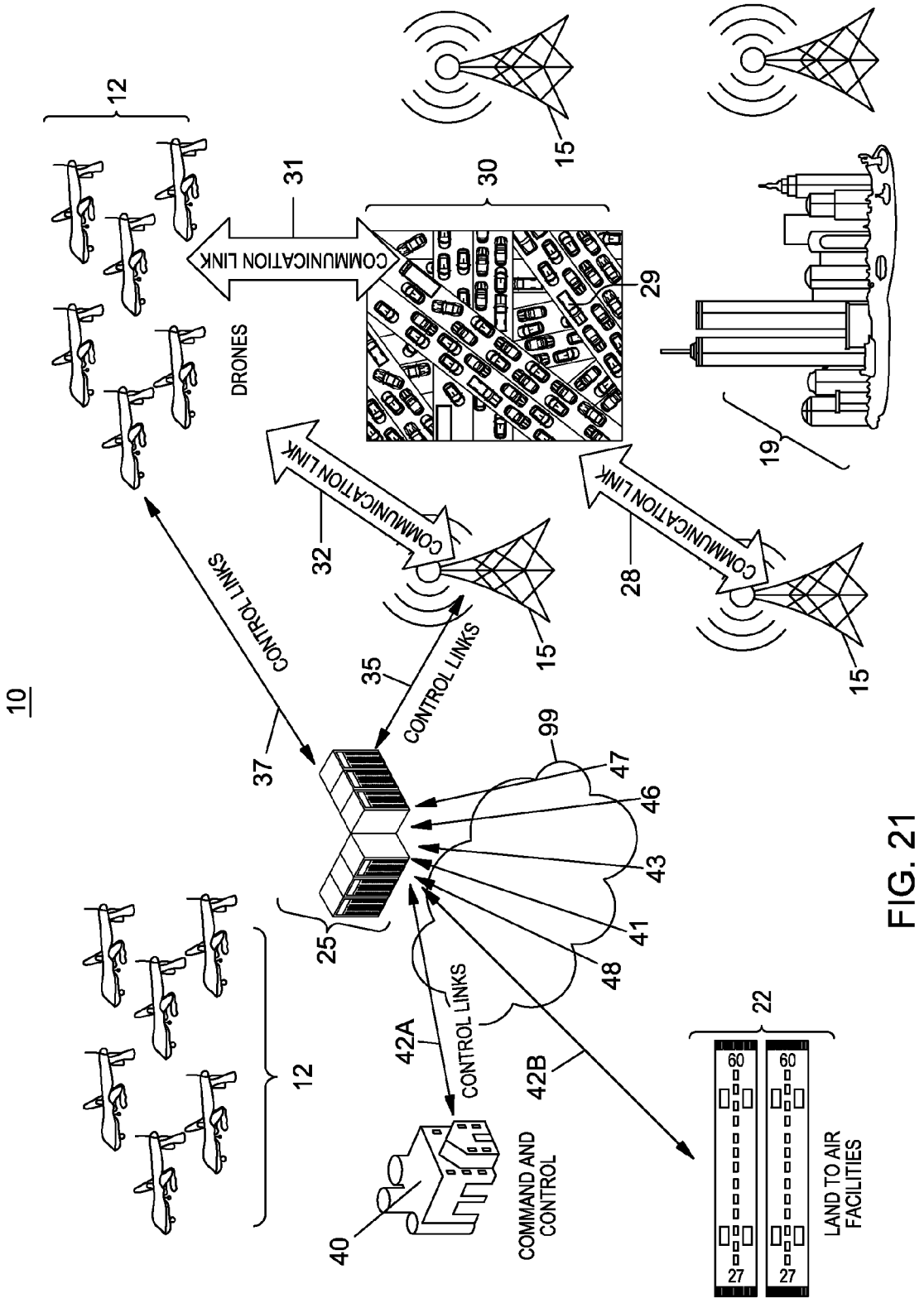

10
12
DRONES
31
COMMUNICATION LINK
30
29
15
19
32
28
CONTROL LINKS
35
37
99
47
46
43
41
48
25
42A
42B
40
COMMAND AND CONTROL
22
60
27
LAND TO AIR FACILITIES

FIG. 21

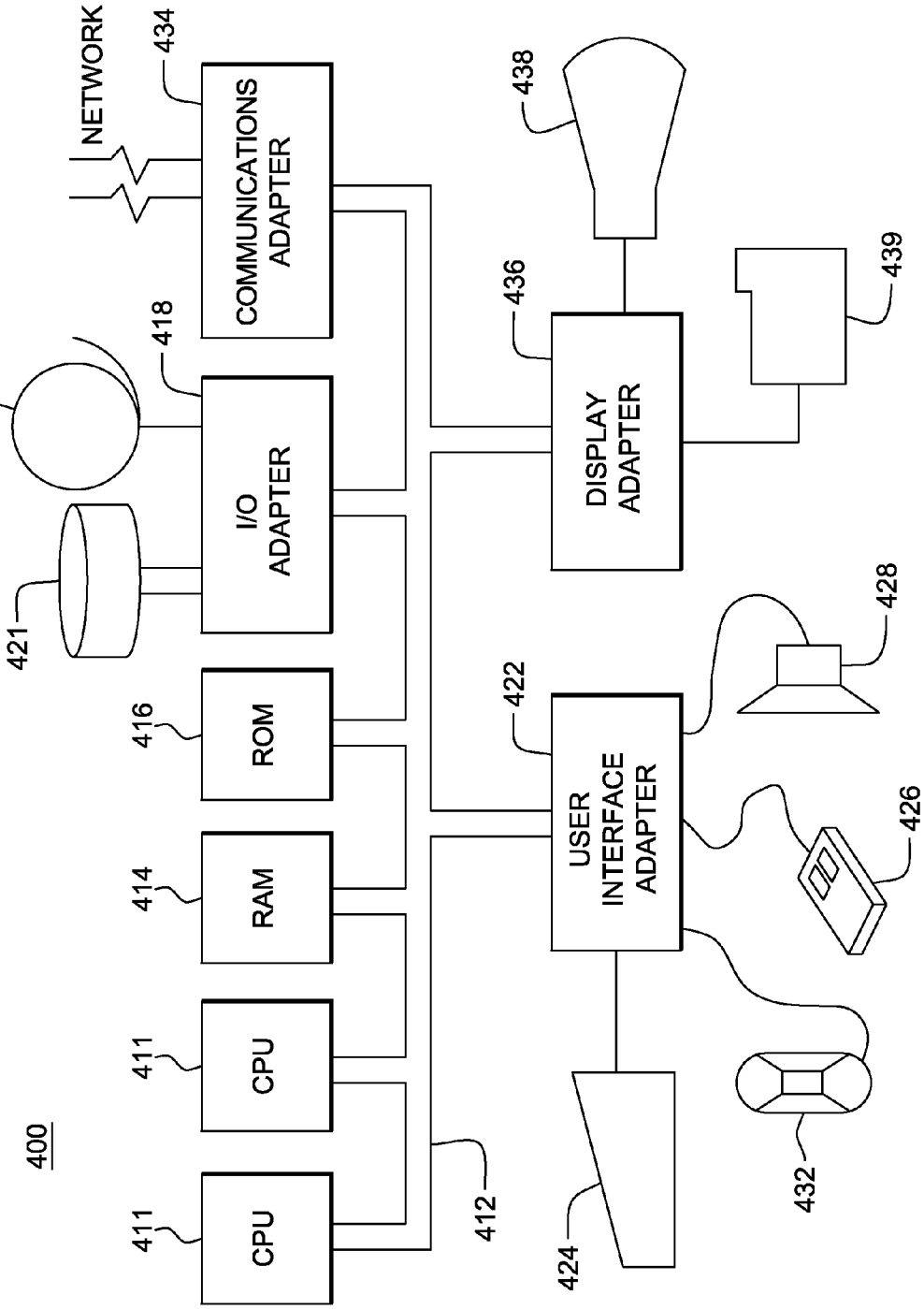

400
CPU
411
CPU
411
RAM
414
ROM
416
I/O ADAPTER
418
COMMUNICATIONS ADAPTER
434
NETWORK
421
440
412
USER INTERFACE ADAPTER
422
DISPLAY ADAPTER
436
438
439
428
426
424
432

FIG. 22

DEPLOYMENT CRITERIA FOR UNMANNED AERIAL VEHICLES TO IMPROVE CELLULAR PHONE COMMUNICATIONS

FIELD OF INVENTION

[0001] The present invention relates generally systems and methods for evaluating and determining the capacity of cellular networks ground based stations, and the tactical deployment and use of telecommunications-equipped unmanned aerial vehicles (UAV) or "drones" to augment the capacities and capabilities of land-based cellular network base stations.

BACKGROUND

[0002] Inadequate mobile device cellular phone coverage is the subject of much frustration for many users of cellular/mobile phones. When customers lack sufficient mobile signal strength, customers incur costs in the form of cellular roaming, as well as dissatisfaction with low sound quality and dropped calls. Some technologies, such as CDMA, have the ability to expand and contract cellular coverage area from a fixed tower. The number of customers registered to a particular cell affects tower range, and the signal strength of a customer can vary dramatically when sampled from the same location at different times/days. Other factors can seriously degrade signal strength, including other RF interference, and multi-path interference created by physical obstacles. Zoning laws can create difficulty in building cellular towers, and even when zoning laws are favorable, availing appropriate space at financially advantageous terms can be difficult and time consuming. In other cases, signal strength may be good but capacity remains low. In these situations, customers appear to have good signal strength, but the throughput for data/voice can be limited because of saturation at the cellular tower's back haul link. Many of these problems occur when unplanned events occur that cause more people to visit the same geographic spot (public demonstration, sporting events, city celebration, etc).

SUMMARY

[0003] A system, method and computer program product for enabling a mobile cellular carrier network to deploy unmanned aerial vehicles (UAVs) equipped with telecommunications devices to act as temporary mobile device cellular network towers, so as to augment signal strength provide cellular service and/or augment the capacities and capabilities of cellular network ground base stations.

[0004] The system, method and computer program product implements functionality for monitoring end users cell phone strengths to determine weak coverage spots, and optimizing when and where a UAV should be dispatched to increase the signal strength or bandwidth to a given area.

[0005] The system, method and computer program product provides for increased on-demand cellular coverage and maps coverage to demands for service.

[0006] The system, method and computer program product performs a mapping, explicitly or implicitly, of where existing coverage may not meet spatial or temporal demand. Based on need, the system and methods identify locations for optimal UAV placement to mitigate insufficient coverage.

[0007] Besides determining when and where to deploy UAVs for coverage, the system and methods determines where people are or where large groups are congregating, and further tracks VIP customers and customers' requests for increased coverages for set durations. To this end, the system and methods implements several predictive methods deploying UAVs in advance of problems to increase cellular coverage in areas where it is predicted that people will converge, in excess of existing cellular capacity.

[0008] In one aspect, there is provided a system for extending cellular phone coverage of a land-based cellular phone network. The system comprises: a memory storage device; a computing device implementing a hardware processor coupled to the memory storage device and configured to: receive information for determining a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time; identify at the hardware processing device, based on an the predicted or actual increased aggregate cellular phone usage demand for the area, whether there exists a mismatch of existing usage coverage compared with the determined increased aggregate demand for that area; determine, based on an identified mismatch, a plan for deploying one or more mobile cellular unmanned aerial vehicle (UAV) having telecommunications equipment configured to extend cellular phone network usage of an existing land-based cellular phone network to the mismatched area; and send, by the computing device, a signal to a facility configured to deploy the one or more mobile cellular UAVs to the mismatched area according to the plan, wherein, responsive to the signal, the one or more mobile cellular UAVs are deployed to the mismatched area to connect with the existing land-based cellular phone network and extend cellular phone usage coverage at the area.

[0009] In one aspect, there is provided a method for extending cellular phone coverage of a land-based cellular phone network. The method comprises: receiving, at a hardware processor of a computing device, information for determining a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time; identifying at the hardware processing device, based on an the predicted or actual increased aggregate cellular phone usage demand for the area, whether there exists a mismatch of existing usage coverage compared with the determined increased aggregate demand for that area; determining, based on an identified mismatch, a plan for deploying one or more mobile cellular unmanned aerial vehicles (UAV) having telecommunications equipment configured to extend cellular phone network usage of an existing land-based cellular phone network to the mismatched area; and sending, by the computing device, a signal to a facility configured to deploy the one or more mobile cellular UAVs to the mismatched area according to the plan, wherein, responsive to the signal, the one or more mobile cellular UAVs are deployed to the mismatched area to connect with and extend cellular phone usage coverage at the area.

[0010] A computer program product is provided for performing operations. The computer program product includes a storage medium, the medium not a propagating signal, the medium readable by a processing circuit and storing instructions run by the processing circuit for running a method. The method is the same as listed above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The objects, features and advantages of the present invention will become apparent to one skilled in the art, in view of the following detailed description taken in combination with the attached drawings, in which:

[0012] FIG. **1** shows a method **50** to detect aggregate weak cell coverage for determining whether to employ a UAV.

[0013] FIG. **2** shows a general method **100** for determining a need to create a UAV-based coverage plan for a location;

[0014] FIG. **3** shows a method for detecting high profile or important customers, and dispatching a UAV cell tower moving with them;

[0015] FIG. **4** depicts an example of a generated "heat map" **200** of an area of New York City showing areas under coverage at a certain times in New York City as predictively determined;

[0016] FIG. **5** depicts a plot of example results **250** of methods employed by the central server **25** to determine dark spots based on aggregate geo-tagged Tweets;

[0017] FIG. **6** depicts an example short term predictive method **300** employed in one embodiment for determining UAV location coverage;

[0018] FIGS. **7**A, **7**B and **7**C show an example of an ebb and flow of city dwellers in an area of New York City which reveal granular insights as to dark spot movement in one embodiment;

[0019] FIG. **8** shows a method **450** that integrates one or more predictive methods employed in one embodiment for determining UAV location coverage;

[0020] FIG. **9** shows an example predictive method **500** employed to predicting crowd convergence by analyzing public transportation information in one embodiment;

[0021] FIG. **10** shows an example predictive method **550** employed to predicting crowd convergence by analyzing credit card and financial transactions in one embodiment;

[0022] FIG. **11** shows an example predictive method **600** employed to predicting crowd convergence by monitoring existing strains on a mobile cellular communications infrastructure;

[0023] FIG. **12** shows an example predictive method **650** employed to predicting a relative crowd convergence by monitoring pending failures on infrastructure;

[0024] FIG. **13** shows an example predictive method **700** employed to monitoring social and conventional media networks for information implying/predicting crowd convergence;

[0025] FIG. **14** shows an example predictive method **750** for configuring an autonomic network of UAVs that autonomically redeploy and regroup to self correct for additional requirements;

[0026] FIG. **15** shows an example method **800** implemented to follow social media data and traffic reports, weather and accident information to redeploy and regroup to self correct for additional cell phone coverage requirements;

[0027] FIG. **16** shows an example method **850** implemented to reroute and deploy the UAV network to take care of the changed conditions in reaction to the traffic/vehicle route changes;

[0028] FIGS. **17**A-**17**C depict example "usage demand" maps generated to represent the relative demand over time for cellular service in a particular setting/area with FIG. **17**A depicting an initial load, and FIGS. **17**B-**17**C showing load changes requiring UAV deployments;

[0029] FIG. **18** shows an example method **950** for configuring UAVs to reposition themselves "on the fly" according to one embodiment;

[0030] FIG. **19** depicts an example methodology **1000** employed for accommodating additional cellular communications coverage from tiers of requesting VIPs;

[0031] FIG. **20** depicts an example methodology **1050** employed for accommodating additional cellular communications coverage based on weather and/or traffic data;

[0032] FIG. **21** shows a system for dispatching mobile cellular aerial vehicles from land to air facilities for extending mobile cell phones usage coverage; and

[0033] FIG. **22** illustrates an exemplary hardware configuration **400** of a central server running and/or implementing the method steps described herein.

DETAILED DESCRIPTION

[0034] FIG. **21** shows a system **10** for determining when and where to dispatch a mobile cellular aerial vehicles **12** (alternately referred to as a "drone", or unmanned aerial vehicle or "UAV") for extending mobile cell phones usage coverage from land to air facilities **22**. In one aspect, the system includes: a cellular phone network depicted by one or more base stations **15** associated with network cells. Each base station **15** corresponds to a cellular phone network cell and enables cellular phone communications from mobile devices. In one aspect, base stations **15** enable cellular phone coverage for devices and/or vehicles in defined geographic areas **19**.

[0035] Types of cellular networks for which UAV's **12** may be deployed to extend mobile phone service coverage according to the methods employed include, but are not limited to: GSM (Global System for Mobile Communications); Universal Mobile Telecommunications System (UMTS); High-Speed Packet Access (HSPA) (e.g., Turbo 3G); Long-Term Evolution (LTE) networks; General Packet Radio Service (GPRS), cdmaOne, CDMA2000, Evolution-Data Optimized (EV-DO), Enhanced Data Rates for GSM Evolution (EDGE), Digital Enhanced Cordless Telecommunications (DECT), Digital AMPS (IS-136/TDMA), and Integrated Digital Enhanced Network (iDEN).

[0036] In one embodiment, as shown, communication links **32** are established between drones **12** and the cellular land based towers **15** using the established cellular network protocols and interfaces. The drone(s) are equipped with cell transceiver/receivers and repeaters and function to connect with an existing cellular network. Each drone may carry its own source of power for mobility, as well as the power source for the cell transceiver and repeater, and its capacity would be much less as compared to land based towers **15**. Advantageously, the drones are not subject to ground based obstructions that might reflect and refract the signals and even at low power capacity and will provide as good coverage as land based cell towers. Once deployed, the altitude of the UAV flight is expected to comply with ant prevailing local laws. For example, laws may be enacted and enforced to create altitude corridors for each type of UAVs. The cell tower drones can fly as high as 1000 feet to 5 miles—but since they should not interfere with commercial passenger—they may be restricted to only a certain altitude band.

[0037] Further, as shown in FIG. **21**, just as cellular land based towers **15** receive communications **28** from mobile communication devices, e.g., from devices in a cell coverage area **19** or from vehicles **29** such as located in an area of vehicle traffic **30** to monitor call volumes, according to one aspect, the drones **12** are configured to establish communications via links **31** from the area **19** or from vehicles **29** such as located in an area of traffic **30** to monitor call volumes from that area. Using cell interfaces and protocols that are the same as cellular land based towers **15** and to either a mobile device

via communication links **31**, or to a mobile tower **15** via communication links **32**, a UAV **12** is configured to extend the cell coverage area that would result from a contraction of a cell's coverage area due to large call volumes.

[0038] In one embodiment, one or more central server(s) **25** are configured to establish bi-directional control links **35** with cell network base stations **15** and establish bi-directional control links **35** with drones **12** over an air interface. From the call volume data inputs communicated via links **35**, **37** etc., the central server(s) monitors and detects aggregate weak cell coverage and creates maps, e.g., "heat" maps of predicted bad or weak coverage areas, where the extensions of coverage may be needed. For example, links **37** from the drones may be analyzed by means of regular feedback from the drones by the central server(s) **25** used to determine whether there exists an unbalance in the load of the drone or other infrastructure. Further, via a wide area network or the Internet **99**, control links **42***a*, **42***b* are established via network connections between the one or more central servers **25** and a command and control center **40** which performs creating the flight plans (where to fly and position) of drones and the active dispatching of the drone from the one or more land to air facilities **22** based on the monitored and detected aggregate cell coverage as determined from the data input to the central server(s) **25**. Via the wide area network, a Virtual Private Network or public network such as the Internet **99**, the central servers **25** may also receive data inputs (feeds) **41** from entities referred to as very important persons (i.e., VIPs such as emergency responders, customers with large contracts, etc.), data feeds **43** from social media networks such as geo-tagged tweets, data feeds **46** from weather services and/or traffic departments, e.g., a local department of transportation (DOT), or like entities that report on traffic conditions in an area **30**, data feeds **47** from news media reporting on events, and data feeds **48** from an infrastructure or entity providing financial transaction data.

[0039] FIG. **19** depicts an example methodology **1000** employed by central servers **25** wherein the VIP data feed **41** may include requests for additional cellular communications coverage from tiers of requesting VIPs. At **1005**, the central servers **25** receive data from tiers (hierarchies) of VIP Customers (e.g., emergency service, contracting customers, etc.) requesting extension of coverage(s) needed. At **1010**, the central servers analyze current/predicted network loads and requested coverage areas to generate a map of needed coverage and extension of coverage needed for each area with levels of fail safe mechanism. A fail safe mechanism is implemented by providing one or more layers of back up coverage by means of drones so that under no plausible circumstances a cell network can be dropped. Then at **1015**, the central servers **25** determine the best locations to position the airborne UAVs that are equipped with cellular repeaters and transceivers to cover for the anticipated weak coverage. Then, at **1020**, the central servers are configured to create a flight plan for the UAV to reach the computed location from the land-to-air facility (i.e., the hovering location) and the return back to the base for each of the drones. At **1025**, the drones are dispatched to fly to their hovering positions and at **1030** are connected to the existing cellular network.

[0040] FIG. **20** similarly depicts an example methodology **1050** employed by central servers **25** wherein at **1055**, the servers receive a data feed **46** including data such as weather data of a particular area from a National Weather Service and/or traffic data of that particular area from a local department of transportation. Using this data input at **1055**, and with additional historic data of cell coverage loads corresponding to similar traffic/weather conditions maintained by the central servers, the central servers at **1060** analyze the current/predicted network loads and generate a predicted map of bad or weak coverage areas, referred to herein as a "heat" map. Based on the generated heat map, at **1065**, the central server is configured to decide whether any area may need additional coverage during a certain time of the day. Then, steps **1070** through **1085** are performed which correspond to steps **1015** to **1030** of FIG. **19**. That is, at **1070**, the central servers **25** determine the best locations to position the airborne UAVs that are equipped with cellular repeaters and transceivers to cover for the anticipated weak coverage. Then, at **1075**, the central servers are configured to create a flight plan for the UAV to reach the computed location from the land-to-air facility (i.e., reach a hovering location) and the return back to the base for each of the drones. At **1080**, the drones are dispatched to fly to their hovering positions and at **1085** are connected to the existing cellular network.

[0041] The foregoing methods of FIGS. **19** and **20** may be likewise employed by the central servers to dispatch UAVs based on predicted cell phone usage coverage according to further data inputs such as the social media network feeds **43** and the financial data feeds **48**, that include data that are analyzed to determine a potential time/place in which cell coverage may be extended by a drone(s) **12**.

[0042] Referring back to FIG. **21**, the central servers **25** may communicate and cooperate with the command and control center to implement methods described in greater detail herein to determine when and where to dispatch a mobile cellular aerial vehicles from land to air facilities. The methods implemented are for: 1) detecting aggregate weak cell coverage; 2) receiving and processing a customer request for increased coverage for a specific time duration; 3) detecting high profile or important customers and move with them (e.g., emergency responders, customers with large contracts, etc); and 4) detecting the convergence, or migration patterns, of large groups. For example, there may be employed one or more of: monitoring a carrier that logs for increased events like "dropped calls"; reading phone users private and public calendars; monitoring a carrier's fixed tower bandwidth and dividing by the number of registered users (e.g., high throughput due to increased users indicates convergence event, whereas higher bandwidth used by a few heavy users could result in not deploying a UAV but performing bandwidth restrictions); and, using geo-tagged tweets.

[0043] For the purpose of this disclosure, "dark spots," are referred to herein to indicate a mismatch of coverage to demand. In embodiments, such representations can of course take on varying graphical forms. For example, there is considered a scenario of a morning commute of vehicles into a city. Demand for cellular coverage can move from the suburb towards the city center as traffic flows inward. Demand accordingly varies over time and location, and reverses direction during the evening rush hours. The problem could become more acute with new technologies around self-driving cars, which may further free up drivers to take on additional tasks while commuting. In this case, an on demand drone will move along with the traffic to provide appropriate cellular coverage.

[0044] FIG. **1** shows a method **50** to detect aggregate weak cell coverage for determining whether to employ a UAV. This method **50** of FIG. **1** is employed by the central servers **25**

(e.g., of a cellular network carrier) for detecting when a large number of collocated people are experiencing suboptimal service for some period of time. Such detection may be accomplished either through the switch or mobile device as current switch technologies have a sophisticated ability to capture information about cell signal, which may be used accordingly. A switch in a mobile network is a device that makes or breaks connection between two or more communication entities and creates communication topologies. The switches are capable of monitoring and reporting the quality and level of communication passing through them. Alternatively, applications may be deployed on a smart phone to capture and send quality information. In either case, this data is used to determine the most effective place for a UAV to be deployed.

[0045] As shown in FIG. **1**, method **50** employed by the central servers includes a first step **55** of monitoring an application, whether on the switch or mobile device, and periodically or asynchronously sending a signal strength reading to an analysis server. Then, at **60**, the central server analyzes all incoming signal metrics and determines areas where significant signal degradation is occurring. At **65**, the server prioritizes areas where UAV coverage would provide the best outcome based on a number of factors. These factors may include, but are not limited to: 1. Number of people with potential improved coverage (e.g., Customer Satisfaction/Revenue generation); 2. Amount of data being generated (e.g., Revenue generation); and 3. Location in terms of competitive coverage (e.g., cost savings based on roaming agreements); Finally, at step **70**, the server sends signal/command to deploy a telecommunications-capable UAV or drone ("cell tower") over highest priority areas.

[0046] In a further aspect, the central servers **25** employ methods for a customer to request increased coverage for a specific time duration. FIG. **2** shows a method **100** for providing by a UAV, responsive to a customer's request for increased coverage for a specific time duration. This method considers situations when, for certain reasons, a specific location may require increased coverage for certain time. Examples include, but are not limited to, conferences in a certain area of a city, or seasonal tourism, e.g., beach goers that flock to a beach for a weekend, or a popular sporting event, etc.

[0047] As shown in FIG. **2**, the method **100** includes a first step **105** of making an estimate of required cellular coverage. This estimate may be based on publicized events, or based on implicit reservations or stated plans for masses to visit an area, e.g., a beach area for a weekend, or a largely populated event in an area. Then, at **110**, considering the current cellular coverage, a determination is made as to whether the existing coverage is adequate for the estimated (temporary) increase in traffic. Then, at **115**, using techniques discussed in greater detail below, the method performs creating a UAV-based coverage plan for the location, if determined one is needed.

[0048] In a further aspect, the central servers **25** employs a method **150** shown in FIG. **3** for detecting high profile or important customers, and dispatch a UAV cell tower moving with them. These high profile or important customers may include, but are not limited to: emergency responders, customers with large contracts, etc. This method considers customers with higher-than-usual needs (e.g. first responders, emergency technicians, or people with premium contracts). This method can also accommodate a tiered category of customers—where a certain group can request superior coverage. In this method, for example, very important customers (i.e., a VIP) may either: 1) make individual requests or 2) the system would actively monitor their signal levels. Upon request by a requestor (e.g., VIP), or detection of poor coverage service, the system could prioritize each VIP—for example, an emergency responder may receive a temporary elevation in priority during emergency scenarios, and which may return to a lower priority after its conclusion. Similarly, individuals may request a temporary VIP status, if willing to pay fees associated with that status, and may provide the predicted usage data—since it is in their interest that additional coverage is provided at an extra charge. To determine who explicitly has such priority, a variety of methods may be employed such as: evaluating, by the system, how many UAVs have lower priority assignments (or are grounded due to lack of need) and determine how many important customers could be covered with a single UAV. For example, if UAV "A" could cover 22 VIPs in Zone 1, and 8 VIPs in Zone 2, then UAV A would be dispatched to Zone 1. In another possible embodiment, the system might prioritize UAV dispatch for purposes of emergency scenarios which outweigh the needs of all other customers.

[0049] As shown in FIG. **3**, method **150** includes a first step **155** of monitoring the designated VIPs for weak signal strength (or a low effective bandwidth). Further, at **160** there is performed monitoring of VIP requests for temporary elevated status. Then, at **165**, the method includes assigning a priority (possibly a weighted priority) based on monitored VIP requests or low bandwidth determinations. A weighted priority is a way of assigning priority based on different factors—where each factor is assigned a different weight(s). The priority is computed as a function of these weighted factors. For example a VIP service may depend on the factors such as i) importance of the activity (such as emergency, business, entertainment, law and order), ii) number of cell lines or persons impacted, iii) repeat business and customer relationship etc., where each of the factors are assigned a different weight and the final priority is computed as a function of these weighted factors. A further determination is made at **170**, FIG. **3** as to how many VIP requests can be handled by a single UAV, and further evaluating the UAVs' current assignments. For example, one or more deployable UAVs may be grounded, others already in the air, etc. Finally, at **175**, the method includes deploying any available UAVs with current assignment that are weighted less than the VIP assignment.

[0050] In a further aspect, the central servers **25** employ a method is provided for detecting the convergence, or migration patterns, of large groups. This method considers movement of dark spots of cellular coverage along a time scale which may, for example, happen when large groups such as commuters converge toward, or diverge away from, a downtown area in the morning and evening. For example, as shown in FIG. **4**, a "heat map" **200** of an area of New York City is depicted showing areas **202**, **204**, **206** and **208** of under coverage at a certain times in New York City. The heat map clusters are determined predictively. In one embodiment, the information used in determining the predictive clustering of group movement, is based on geo-tagged tweets from mobile devices.

[0051] In one embodiment, FIG. **5** depicts a plot of results **250** of methods employed by the central server **25** to determine dark spots based on aggregate geo-tagged Tweets, which data may be obtained from the Twitter® service. Par-

ticularly, Twitter® provides geo-tagged tweets with latitude and longitude coordinates in a city, e.g., New York City. FIG. **5** specifically shows the aggregated geo-tagged tweets referencing the word "Sandy" between certain days, e.g., six (6) days in October 2012, at a certain time of day. Using known techniques, tweet locations are aggregated to census blocks. Dark spots **252**-**256** indicate the number of Tweets in order of aggregated amounts with small dark spots **252**, **254** showing areas of sourcing small amount of aggregated Tweets, e.g., 50, or 100, and larger DOTs **256** indicating areas sourcing larger amounts of Tweets, e.g., 150. These dart spots denote inadequacy of cellular coverage.

[0052] Input of social media mainly refers to use of Twitter®, Facebook® posts—as a large volume of data are already geo-tagged in Twitter®—because pictures taken by mobile handheld devices are geo tagged. Google+ also makes use of geo-tagging from the Google Map to which it is connected as well as Android OS that is part of many mobile systems. Considering that a large number of mobile devices use either Android® or Apple® IoS—that use Google map mostly—coverage of a large portion of mobile device users is enabled. Windows® CE provides an equivalent system to Google as well.

[0053] As shown in FIG. **6**, a short term predictive method **300** is employed including a first step **305** for mapping each dark spot denoting inadequacy of coverage to geographic locations. Then, at **310**, the method includes mapping how each spot moves in time, and then extrapolating to find the next possible location.

[0054] In one embodiment, to locate "dark spots" the cellular communications network towers, repeaters and connectors obtain data to measure the health of the network along with how much traffic and the capacity usage using methods known in the art. However, this data is used to compute first and second order derivatives in both time as well as space domains to determine both the direction of the flow as well as the speed of the direction of the flow. These results enable to predictively determine where there is the need for additional coverage using a drone.

[0055] Then, at **315**, the method relocates UAVs with the movement of the spots for adequate coverage along needed corridors. Then, at **320**, the method includes detecting when two dark spots have merged, and determining whether two or more UAVs approach the same area—i.e., the coverage might be shared by the UAVs, or determining whether one UAV cell tower may handle the composite load.

[0056] Each UAV employing cellular transceivers and repeaters is configured to handle any data interference problems in the same way cellular data and the devices themselves avoid interference: by using different bands of frequencies, and within the same band of frequency, using time division multiplexing (TDMA) and frequency division multiplexing (FDMA). These data interference techniques would be used if two or more UAV's are needed for increased coverage.

[0057] In a further embodiment, a longer term predictive method is employed. In this method, the central server **25** receives as input historical traffic data from a transportation data source, e.g., a department of transportation, and others sources to determine how traffic patterns change, based on the time of the day, month, weather, and season. The method creates a predictive map and plans for moving the UAV cell tower along the necessary corridors. One method employed for providing predictive traffic information is described in commonly-owned U.S. Pat. No. 8,150,611 the whole contents of which is incorporated by reference as if fully set forth herein.

[0058] FIGS. **7**A, **7**B and **7**C show an example ebb and flow of city dwellers in an area of New York City. The specific observations such as shown in FIG. **7**A-**7**C reveal granular insights. FIG. **7**A depicts cellular phone usage data **350** captured on a particular afternoon on a weekend day in winter season, e.g., February. As shown in FIG. **7**A, there is indicated a high call usage activity **350** from residential areas bordering the Central Park **351**. FIG. **7**B shows the same afternoon weekend day during a summer month, e.g., July, with cell phone usage activity **352** shifting to the southern end of Central Park **351**. FIG. **7**C shows a delta computation where the winter map of FIG. **7**A is subtracted from the summer map of FIG. **7**B to reveal the calling pattern **354** more clearly as the residents in the homes surrounding the park leave the city during summer weekends and those who remain flock to the park.

[0059] Thus, in the manner as described in FIGS. **1**-**7**C, the system and method permits increased customer satisfaction with cellular service, and lowers the costs necessary to deploy fixed infrastructure. In doing so, it permits sophisticated approaches and new applications for the burgeoning field of domestic UAV use.

[0060] In further embodiment, the central servers employ methods that provide predictive deployment criteria for unmanned aerial vehicles to improve communications. More particularly, in a further embodiment, there is provided increased cellular coverage by predicting where crowds will converge and deploying UAVs in advance of the predicted event. Several usage examples follow:

[0061] In a first usage example, a public protest is planned by a large group of citizens in a downtown area of New York City. The number of people converging on this atypical area will normally cause a strain on the cellular communications capability creating spotty and degraded cell service. However, using the methods described herein, the system is monitoring public transportation for anomalies. As the time approaches and citizens begin to gather the system sees a trending increase in the number of people paying for taxi fares that terminate at or near Wall Street. The system also notices an increasing number of people using busses and subways on lines that terminate near Wall Street. In anticipation that the trends will continue to increase, several telecommunications companies deploy UAVs to the Wall Street sector to handle the predicted increase in voice and data traffic.

[0062] In a second usage example, a large number of sightseers are part of a guided tour that includes several bus loads of people. In addition there was a large world championship game the day before where the hometown team won, and as a result there will be a lot more people gathering to celebrate that evening than is normal. The system performs monitoring for trends in financial transactions which would give clues to just such an unplanned convergence of people. The system begins to pick up increased transactions for parking meters and issued citations for illegal parking just before the typical dinner hour. It then begins to detect increases in the number of people visiting bars and street-side venues and even sees a general migration towards public gathering places. The system determines that there is a likely chance that the trend will continue by monitoring the social media "buzz" where people

are recommending their friends join them for the celebration. As a result, UAVs are deployed in advance of any degraded signals or capacity problems.

[0063] Several predictive methods may be employed for the central servers to deploy UAVs in advance of problems to increase cellular coverage in areas where it is predicted that people will converge, in excess of cellular capacity. FIG. **8** shows a method **450** that integrates one or more predictive methods. At **455**, the central server **25** of system **10** receives department of transportation and other real-time public transportation data, e.g., and/or for hire transport data, analyzes the data, and predicts crowd convergence by analysis of public transportation. The transportation data received is public data available in real time such as is often used by many GPS algorithms to provide real time traffic analysis. The real time transportation data received is monitored may include: capturing taxi or ride-sharing pick-up/drop off locations and the changes in frequency over time; and capturing usage of the number of people using buses and subways and their known destinations. Then at **460**, the method includes analyzing credit card and financial transactions to predict crowd convergence. Then, at **465**, the method includes monitoring existing strains on infrastructure to predict relative crowd convergence. Then, at **470**, the method includes monitoring pending failures on infrastructure to predict relative crowd convergence. Finally, at **475**, crowd convergence is predicted by monitoring social and conventional media for information implying crowd convergence.

[0064] FIG. **9** shows a detailed method **500** representing the next step **455**, FIG. **8** directed to predicting crowd convergence by analyzing public transportation information, such as provided by data feeds **47** received at the central servers **25**. The detailed method includes: at **505**, receiving taxi cab destination pick-ups and drop-off locations data in additional to receipt of information regarding public use of buses and trams and data representing subway tickets that have been scanned and being currently scanned (in real-time) for a subway line (s). Then, at **510**, these changes are measured against a baseline. The baseline is computed assuming the average demand for facilities and infrastructure. The baseline might show some normal diurnal or seasonal variations and those are normally accounted for, however may not take into account for exceptional variations. The baseline is based on a historic data and perspective. Normally a baseline may account for a small percentage (say up to 10% of random variations), any variations beyond a nominal variation may cause problem at the cellular infrastructure. At **515**, a determination is made whether a change is detected from the baseline, and if a change is detected, then perform further analyzing of the location where people are going and the rate of change to that location. Then, at **520**, there is performed detecting if a threshold change compared to threshold is met that indicates a significant number of people will move in that same direction, and in response, initiating deployment of the UAV cell tower if detected above threshold. At **525**, a further analysis is made to determine whether the exact destination of people movement is known or whether a directional aspect is determined, and in response, initiating deployment of the UAV cell tower to a roaming pattern accordingly. At **530**, there is performed a further step of monitoring the number of connected devices in the UAV's roaming pattern—and re-evaluating its assignment based on determining where most people are.

[0065] FIG. **10** shows a detailed method **550** representing the next step **460**, FIG. **8** directed to predicting crowd convergence by analyzing credit card and financial transactions. The detailed method includes monitoring for changes in the normal trends of financial transactions, including credit, debit, cash (if applicable), ATM withdrawals, etc. It measures unanimous data in large aggregate conditions for trends or changes in velocity or rate of change over a normal historical record. At **555**, FIG. **10** there is depicted the step of monitoring for financial transactions within scope (credit, cash, withdrawals, etc). Then, at **560**, the method includes creating a baseline from the financial transaction data received/monitored and created according to a computed assuming the average demand for facilities and infrastructure. This data is then analyzed for changes, e.g., changes to a rate of change. Then, at **565**, there is performed analyzing the data for changes in a rate of change. At **570**, there is performed determining whether there is an occurrence of an increased number of financial transactions and then analyzing to determine a type of transaction. Then at **575**, there is performed determining if it is a type of transaction that implies physical convergence or movement [like purchasing a good or service at a location] in which in response, that transaction is counted in the overall analysis. Otherwise, at **575**, if it is determined that it is a type of transaction that doesn't imply convergence (e.g., as in the purchase of a good from an online retail store) then that transaction is not counted in the overall analysis.

[0066] FIG. **11** shows a detailed method **600** representing the next step **465**, FIG. **8** directed to predicting crowd convergence by monitoring existing strains on a mobile cellular communications infrastructure. This method monitors rising workload on existing fixed or mobile cellular infrastructure, and deploys additional capacity if such strains indicate a potential over-capacity scenario. In one embodiment, the infrastructure may also include mixed cellular infrastructure, where part of the network depends on other form of communication network such as copper, fiber optics, microwave, satellite or other form of networks. At **605**, FIG. **11**, there is depicted the step of receiving traffic data at the central servers **25** and analyzing the data for monitoring for traffic increases on existing cellular infrastructure. Then, at **610**, there is depicted a step of determining and reporting if the load on any single piece of, or any proximate group of, infrastructure exceeds a certain predefined threshold. An example threshold may include a 10% of the computed baseline. Then, at **615**, the method includes initiating a deployment of additional mobile cellular capacity to the area exhibiting the strain on infrastructure.

[0067] FIG. **12** shows a detailed method **650** representing the next step **470**, FIG. **8** directed to predicting a relative crowd convergence by monitoring pending failures on infrastructure. This method monitors error or fault conditions on existing fixed or mobile cellular infrastructure, and deploys additional capacity if such faults indicate that a failure (or service degradation) is imminent. In one embodiment, this method presumes a "relative" crowd by which whatever numbers of people inhabit a given area will have demands greater than the remaining service capacity once the switch fails. That is, a relative traffic migration occurs when a particular part of the infrastructure such as a cellular tower or a transceiver fails or malfunctions in a cellular infrastructure and other cellular towers or a transceivers need to accommodate this extra traffic which is different than their nominal load. At **655**, FIG. **12**, there is depicted the functionality of the central servers **25** of monitoring for, and/or preemptively detecting when, errors or fault conditions occurring on existing cellular

infrastructure begin to occur. Such errors may or may not be related to cellular load conditions, and will more generally indicate software or hardware issues. Then, at **660** the method includes analyzing each of any detected errors or fault conditions to determine if the condition indicates that either full failure or service degradation is imminent. Then, at **665**, there is deployed additional mobile cellular capacity, e.g., a UAV cell tower, to the area being served by the problematic infrastructure.

[0068] FIG. **13** shows a detailed method **700** representing the next step **475**, FIG. **8** directed to monitoring social and conventional media networks for information implying/predicting crowd convergence. The central services **25** monitor social and conventional media to determine through automated fashion where crowd convergence in excess of existing cellular capacity may occur. At **705**, FIG. **13**, there is depicted the step of monitoring in the social media feeds (e.g., geotagged tweets) any mentions of events in an automated fashion, e.g., textual analysis, sentiment analysis, etc., to determine when and where gatherings of people may occur. Then, at **710**, the method includes estimating the size of events through automated fashion, e.g., venue size, ticket sales, RSVPs, or other analogous indicators. At **715**, the method includes comparing the estimated crowd size with existing or planned cellular capacity. Finally, at **720**, the method initiates preemptive deployment of additional cellular capacity if determined that the crowd size is estimated to be greater than, or near, cellular capacity.

[0069] Illustrative and non-limiting example usages of the methods described herein above for providing increased cellular coverage by reacting to crowd movements in real time and deploying UAVs in to redeploy themselves as quickly as possible are now provided.

[0070] Example Usage 1: For application at coverage scales ranging between 1-10 miles. City vehicle traffic is planned for the usual roads such as shown in the system of FIG. **21** and traffic is moving smoothly as predicted. Suddenly there is an accident causing mile after mile of stop and go traffic. Each occupant in the vehicle trying to communicate to their place of work as well as home regarding the possible delay—causing unusually large call volume near the place of the accident. The occupants are at the same time trying to report the incident, or trying to find more about the incident in social media. In such a scenario, existing UAVs would be redeployed with additional capacity and new UAVs are relocated to back up other UAVs to fill up the gap for the needed capacity.

[0071] Example Usage 2: For application at coverage scales ranging between 5-30 miles. As a result of a sudden change in weather condition, vehicle traffic is moving very slow on a weekday morning and cellular towers are having trouble keeping up with the number of subscribers in their vicinity. Since traffic is moving even slower as it gets closer to the city, the hand over from one tower to the next is getting affected as well. This requires a certain additional UAVs to support the existing cell towers and create a smooth hand over of calls.

[0072] Example Usage 3: For application at coverage scales ranging between 5-30 miles. As a result of an accident in a main road, traffic is rerouted to the side roads—creating additional traffic burdens on the side roads. People are now consulting their mobile device traffic applications and choosing to use alternate suggested routes as opposed to the usual route. Since these alternate roads are not meant to handle such a large volume of traffic who are trying to communicate to their place of work as well as home regarding the possible delay—this causes unusually large call volume. The occupants are at the same time trying to report the incident or trying to find more about the incident in the social media. In such a scenario, existing UAVs would be redeployed with additional capacity, and new UAVs are relocated to back up other UAVs to cover the gap for the additional demand.

[0073] Example Usage 4: For application at coverage scales ranging between 500 feet to 5 miles. A popular game such as football's Super Bowl is occurring in a stadium. Small sized UAVs are deployed over the field to account for the additional usage required for the spectators and their need to communicate and be connected with the social media. To avoid conflict the supporters of Team A are seating at a particular location that is avoided by the supporters of Team B. Team A scores a touch down and the supporters of Team A go abuzz on the social media and supporters of Team B go quiet with astonishment. In such a case existing UAVs are redeployed with additional capacity and new UAVs are relocated to back up other UAVs to fill up the gap for the needed capacity.

[0074] Example Usage 5: For application at coverage at any scale. A network of UAVs, i.e., a set or a cluster of UAVs creating a communication network such as a peer-to-peer or a master-slave network. are deployed to support the land-based cellular communications network infrastructure. A few of the cell towers as well as UAVs suddenly malfunction—creating a gap in the network. In such a case existing UAVs are redeployed with additional capacity and new UAVs are relocated to back up other UAVs to fill up the gap for the needed capacity.

[0075] In a further embodiment, the system and methods at the central servers **25** will redeploy cell tower equipped UAVs in reaction to one or more problems to increase cellular coverage in areas where it is determined call volume suddenly goes in excess of cellular capacity. In this embodiment, the system configures itself as an autonomic network of UAVs that autonomically redeploy and regroup to self correct for additional requirements. By following the social media and local Department of Transportation (DOT) traffic reports, weather reports and accident information reports, UAVs may be redeployed and regrouped to self correct for additional requirements. In reaction to the traffic—vehicles change their route and communicate that either through a vehicular network or through a server to a central communication hub. The communication hub in turn re-routes and deploys the UAV network to take care of the changed conditions.

[0076] FIG. **14** shows a detailed method **750** for configuring an autonomic network of UAVs that autonomically redeploy and regroup to self correct for additional requirements. The method at **750** includes a first step of: creating a plurality of clusters of UAVs and/or static cellular towers in the vicinity or a coverage area. Then, the method at **760** includes establishing communication with and between each of the UAVs and/or static cellular towers in the vicinity belonging to a cluster, and with and between a designated leader UAV. The designated leader monitors the functioning of the rest of the UAVs in an ad hoc cluster and assign loads to each of the UAVs in the network. The method at **765** then includes establishing that each cluster support a particular set of customers. Thus, as shown at **770**, when there is detected that an additional need for cellular service arises—the clusters are autonomically reconfigured to support the need. Further, at **775**,

there is made a determination whether one or more members of a cluster fail. In response, the clusters are again reconfigured to support the need. Finally, at **780**, the method includes reconfiguring the clusters when additional UAVs are repositioned or brought back into service to support the need.

[0077] FIG. **15** shows a method **800** implemented to follow the social media data and DOT traffic reports, weather and accident information to redeploy and regroup to self correct for additional requirements. In a first step **805**, the method includes monitoring the social and the news media in real time for occurrence of accidents or traffic back ups. Then, the method returns to step **770**, FIG. **14** so that each cluster can be reconfigured to support the need.

[0078] FIG. **16** shows a method **850** implemented to reroute and deploy the UAV network to take care of the changed conditions in reaction to the traffic, e.g., detecting that vehicles have changed their routes and communicate that either through a vehicular network or through a server to a central communication hub. The communication hub in turn reroutes and deploys the UAV network to take care of the changed conditions. Thus, in FIG. **16**, at **855** the method includes predictively recomputing using the DOT, news and traffic data feeds to the central server **25** where the traffic would be at a certain time in the future. This may occur responsive to when traffic re-routes to different locations in reaction to an accident or a traffic event as opposed to their anticipated locations. Then, at **860**, in response to the changed configuration(s), the UAV clusters are reconfigured and redeployed to support the modified need.

[0079] In additional embodiments, the system employs methods for self-optimizing UAV deployments over a geographical region. That is, while the solution to improve cellular coverage by deploying a single UAV to address a specific gap is addressed, methods are provided to further address a scenario where multiple UAV's are deployed to address their individual objectives. In the further methods, multiple UAVs are configured to discover each other, build a common "usage demand map" and then use that map to calculate an areal relocation plan that ensures the individual objectives are met but also allows a neighboring UAV to supplement the coverage services of another UAV thus creating an optimal combined deployment plan. Thus, there is addressed using multiple cell-tower equipped UAVs, and optimizing the configuration of multiple cell-tower equipped UAVs within an area to accomplish their individual objectives as well as reach an ideal combined solution based on positioning.

[0080] Thus, the system enables UAVs to reposition themselves "on the fly" and to achieve a best fit configuration for service, based on detection of their own service demands and communication with other UAVs in a given region. For example, FIG. **17**A depicts a grid **900**, i.e., a "usage demand" map generated to represent the relative demand for cellular service in a setting, e.g., an urban setting. In the grid **900** of FIG. **17**A, reference to L==Low usage demand, M==Medium usage demand, and H==High usage demand. The indicators may represent any unit of geographic measurement, e.g., from a city block, to square mile, to any other applicable measure of area.

[0081] Then, it may be subsequently detected that an initial deployment, based on changed demand from factors determined by methods described herein, results in UAV placement as indicated by the grid **920** of FIG. **17**B. The consecutive numbers labeled **1**, **2**, **3** in the grid **920** of FIG. **17**B correspond to deployed UAVs, UAV**1**, UAV**2** and UAV**3**, respectively, for tracking purposes.

[0082] However, based on methods described herein, a problem subsequently is detected to exist in that the loads on UAVs **1** and **2** become much heavier than that on UAV**3**. For example, this may be because UAVs **1** and **2** are positioned much closer to heavy pockets of cellular demand than is UAV **3**. Correspondence between the three UAVs labeled **1**, **2** and **3**, during which they compare their respective workloads, reveal this to be the case. By triangulation, the UAVs can determine that the bulk of the cellular demand is occurring at points north. They can then quickly agree on a "best fit" organization to balance cellular traffic, resulting in a configuration such as the shown by the grid **930** in FIG. **17**C.

[0083] Thus, in a further aspect, a method is invoked to detect newly deployed drones, create a common "usage demand map", and then calculate and reposition drones to an optimal configuration. In this embodiment, a "best fit" occurs when the UAVs, e.g., UAV**1**, UAV**2** and UAV**3**, are positioned so that they have either approximately the same amount of network traffic passing through them, or more likely, a normalized equivalent amount of traffic. Thus, for example, if the switches have differing capacities, they could each be running at the same level, for instance 40-45% of overall capacity.

[0084] Furthermore, in this mobile infrastructure, the method regularly conducts such reorganization, e.g., every 30 seconds, 5 minutes, or 30 minutes, such information could be exchanged between and amongst the UAVs, and the infrastructure would reposition itself such that the mobile capacity was fairly balanced between the existing cellular workload.

[0085] FIG. **18** shows a detailed method **950** for dynamic reconfiguring of UAVs to reposition themselves "on the fly" and to achieve a best fit configuration for service, based on detection of their own service demands and communication with other UAVs in a given region. Using the methods described herein, a usage demand map or "heat" map is generated that includes predicted areas of bad or weak cell phone usage coverage. Then at **960**, a single or multiple UAVs is/are deployed as per requirements based on methods described herein. Then at **965** the UAV(s) are connected to the existing cellular network using known cellular phone infrastructure protocols and interfaces. Then, at **970**, a determination is made as to whether there occurs any change in the system creating an unbalance in the load of the drone or other infrastructure systems. If no load change occurs, the process remains idle until such a determination is made. If there is a determined load change, then the process proceeds to **975** to initiate a re-computation of the "usage demand map" (such as shown in FIG. **17**A) that is shared amongst all UAVs. Then, at **980**, the method re-computes the best locations to position the airborne UAV laden with cellular repeaters and transceivers to accommodate for the weak coverage. As part of step **980**, the method may perform calculating an optimal placement of UAV's such that: 1. the original objective for each UAV(s) is(are) met; and 2. The positioning allows it to offload network demand from one or more surrounding UAVs. Then, at **985**, the method performs creating a flight plan to the reach the computed hovering location from the base and the return back to the base for each of the drones. Then, at **990**, the method includes repositioning all drones to the optimal location. Then, at **995**, each of the drones is reconnected with the existing cellular network. It is understood that the process

may return to step **970** to update the "usage demand map" responsive to any detected load changes in the drones or infrastructure network.

[0086] Thus, the self-correcting method is employed when there is a sudden shift in the usage demand map ("heat map") as discussed herein above. This method considers the dynamic situation when things change unpredictably: For example, 1) when one of the UAV loses power or is decommissioned; or 2) the load of some UAV has increased whereas some other UAV does not have enough load. An algorithm is employed to dynamically balance the load among all the working UAVs using such as the algorithm described in commonly-owned U.S. Pat. No. 7,328,363 (the whole contents and disclosure of which is incorporated by reference herein) with one significant difference: the UAVs cannot change the location instantaneously and reposition themselves. Thus, additional steps are employed:

1. If all the UAVs are close by that is all near the hot spot, do not reposition any of the UAVs but essentially re-balance the load based on the algorithm described in U.S. Pat. No. 7,328,363.

2. If one or more UAVs are far off, the algorithm in U.S. Pat. No. 7,328,363 is modified to consider the actual physical distance of the UAV in the network distance as described there in and minimize/find the optimal physical distances of all the UAVs to determine the optimal modified configuration and placement of all the UAVs for repositioning accordingly.

[0087] As an example implementation, there is considered a deployment of a single UAV (per requirements of methods herein). A determination is made as to whether other UAV's have already been deployed in the surrounding region. If other UAV's have already been deployed, then a "usage demand map" is built that is communicated and shared amongst all the UAVs. Then, the method calculates the optimal placement of the UAV's such that the original objective for that single UAV is met, and that its positioning permits it to offload network demand from one or more of the prior deployed surrounding UAVs. Then, based on the usage demand map, all drones are repositioned to the optimal location. These steps are repeated until a new single UAV is deployed or removed, in which case the method continues to determine the presence of other deployed UAVs in the area, building the usage map and communicating it amongst all UAV's for optimal repositioning. Whether, a new UAV(s) is(are) deployed, the system periodically updates the "usage demand map", communicates it among the UAVs, and recalculates the optimal positioning of the UAVs based on the updated usage map.

[0088] It should be noted that while existing cellular network infrastructures are often created with capacity plans which include peak or near-peak traffic, resulting in relatively high costs for leasing space, site installation, repair, maintenance, and other expenses, the deployment and use of UAVs in the manner as described herein will mitigate that problem by permitting fixed infrastructure to be sized for lower capacity, thus saving cost, and augmenting this capacity by UAV when needed.

[0089] FIG. **22** illustrates an exemplary hardware configuration **400** of a central server running and/or implementing the method steps described herein with respect to FIGS. **1-3**, **6**, **8-16** and **19-21**. The hardware configuration preferably has at least one processor or central processing unit (CPU) **411**. The CPUs **411** are interconnected via a system bus **412** to a random access memory (RAM) **414**, read-only memory (ROM) **416**, input/output (I/O) adapter **418** (for connecting peripheral devices such as disk units **421** and tape drives **440** to the bus **412**), user interface adapter **422** (for connecting a keyboard **424**, mouse **426**, speaker **428**, microphone **432**, and/or other user interface device to the bus **412**), a communication adapter **434** for connecting the system **400** to a data processing network, the Internet, an Intranet, a local area network (LAN), etc., and a display adapter **436** for connecting the bus **412** to a display device **438** and/or printer **439** (e.g., a digital printer of the like).

[0090] As will be appreciated by one skilled in the art, aspects of the present invention may be embodied as a system, method or computer program product. Accordingly, aspects of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

[0091] The present invention may be a system, a method, and/or a computer program product. The computer program product may include a computer readable storage medium (or media) having computer readable program instructions thereon for causing a processor to carry out aspects of the present invention.

[0092] The computer readable storage medium can be a tangible device that can retain and store instructions for use by an instruction execution device. The computer readable storage medium may be, for example, but is not limited to, an electronic storage device, a magnetic storage device, an optical storage device, an electromagnetic storage device, a semiconductor storage device, or any suitable combination of the foregoing. A non-exhaustive list of more specific examples of the computer readable storage medium includes the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a static random access memory (SRAM), a portable compact disc read-only memory (CD-ROM), a digital versatile disk (DVD), a memory stick, a floppy disk, a mechanically encoded device such as punch-cards or raised structures in a groove having instructions recorded thereon, and any suitable combination of the foregoing. A computer readable storage medium, as used herein, is not to be construed as being transitory signals per se, such as radio waves or other freely propagating electromagnetic waves, electromagnetic waves propagating through a waveguide or other transmission media (e.g., light pulses passing through a fiber-optic cable), or electrical signals transmitted through a wire.

[0093] Computer readable program instructions described herein can be downloaded to respective computing/processing devices from a computer readable storage medium or to an external computer or external storage device via a network, for example, the Internet, a local area network, a wide area network and/or a wireless network. The network may comprise copper transmission cables, optical transmission fibers, wireless transmission, routers, firewalls, switches, gateway computers and/or edge servers. A network adapter card or network interface in each computing/processing device receives computer readable program instructions from the network and forwards the computer readable program

instructions for storage in a computer readable storage medium within the respective computing/processing device.

[0094] Computer readable program instructions for carrying out operations of the present invention may be assembler instructions, instruction-set-architecture (ISA) instructions, machine instructions, machine dependent instructions, microcode, firmware instructions, state-setting data, or either source code or object code written in any combination of one or more programming languages, including an object oriented programming language such as Smalltalk, C++ or the like, and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The computer readable program instructions may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). In some embodiments, electronic circuitry including, for example, programmable logic circuitry, field-programmable gate arrays (FPGA), or programmable logic arrays (PLA) may execute the computer readable program instructions by utilizing state information of the computer readable program instructions to personalize the electronic circuitry, in order to perform aspects of the present invention.

[0095] Aspects of the present invention are described herein with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems), and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer readable program instructions.

[0096] These computer readable program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer readable program instructions may also be stored in a computer readable storage medium that can direct a computer, a programmable data processing apparatus, and/or other devices to function in a particular manner, such that the computer readable storage medium having instructions stored therein comprises an article of manufacture including instructions which implement aspects of the function/act specified in the flowchart and/or block diagram block or blocks.

[0097] The computer readable program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other device to cause a series of operational steps to be performed on the computer, other programmable apparatus or other device to produce a computer implemented process, such that the instructions which execute on the computer, other programmable apparatus, or other device implement the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0098] The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods, and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of instructions, which comprises one or more executable instructions for implementing the specified logical function (s). In some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts or carry out combinations of special purpose hardware and computer instructions.

What is claimed is:

1. A system for extending cellular phone coverage of a land-based cellular phone network comprising:

a memory storage device;

a computing device implementing a hardware processor coupled to said memory storage device and configured to:

receive information to determine a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time;

identify, based on an said predicted or actual increased aggregate cellular phone usage demand for said area, whether there exists a mismatch of existing coverage compared with said determined increased aggregate usage demand for that area;

determine, based on an identified mismatch, a plan for deploying one or more mobile cellular unmanned aerial vehicle (UAV) having telecommunications equipment configured to extend cellular phone network coverage of an existing land-based cellular phone network to the mismatched area; and

send, by the computing device, a signal to a facility configured to deploy said one or more mobile cellular UAVs to said mismatched area according to said plan,

wherein, responsive to said signal, said one or more mobile cellular UAVs are deployed to said mismatched area to connect with said existing land-based cellular phone network and extend cellular phone usage coverage at said area.

2. The system as claimed in claim **1**, wherein to determine said predicted or actual increase in aggregate cellular phone usage demand, said hardware processor is configured to:

detect one or more of: incoming signal strengths from mobile phone users received at a fixed land-based cellular phone tower associated with said area, or a number of dropped call events detected of from a fixed land-based mobile cellular tower to other fixed land-based mobile cellular towers.

3. The system as claimed in claim **1**, wherein to determine said predicted or actual increase in aggregate cellular phone usage demand, said hardware processor is configured to:

monitor said cellular phone network land-based fixed cellular phone tower bandwidth, and calculate a metric using said monitored fixed cellular phone tower bandwidth divided by a number of registered users.

4. The system as claimed in claim **1**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time.

5. The system as claimed in claim **4**, wherein said information indicating a convergence or migration includes one or more customer requests for increased coverage at said area for a specific time duration, wherein to identify said area, said hardware processor is configured to:

detect customer requests from one or more of: high profile users, very important customers or customers having a contract with a cellular phone network carrier, emergency responders, personal calendar events shared voluntarily with the cellular phone network carrier.

6. The system as claimed in claim **4**, wherein to determine from said information indicating a convergence or migration, said hardware processor is configured to:

predict clustering of mobile device user group movement from said information; and

generate a usage demand map indicating the predictive clustering of said mobile device user group movement at an area,

using said usage demand map is used to identify whether one or more areas may need additional coverage during a time of the day.

7. The system as claimed in claim **4**, wherein said data indicating a convergence or migration is based on received transportation information including one or more of: data representing hired vehicle destination pick-up and drop-off locations, data representing current use of public transportation vehicles, data representing subway tickets sold to mobile phone users, wherein to determine from said information indicating a convergence or migration, said hardware processor is configured to:

analyze from said received transportation information a location where people are going and a rate of change to that location; and

detect if a rate of change compared to threshold is achieved that indicates a significant number of people will move in that same direction.

8. The system as claimed in claim **6**, wherein to predict clustering, said hardware processor is configured to:

detect a destination of people movement; or

detect a directional aspect of people movement; and

in response to a destination or directional aspect detection, generate a plan for deploying said one or more mobile cellular UAVs to a roaming pattern to accommodate said destination or directional aspect; and

send signals are sent to a facility to deploy and dispatch said one or more mobile cellular UAVs.

9. The system as claimed in claim **8**, wherein signals are sent to a facility according to a plan to deploy and dispatch two or more mobile cellular unmanned aerial vehicles, said hardware processor is further configured to:

detect a merging of two or more group movements that provides a composite load to an area;

determine whether two or more mobile cellular UAVs approach that area; and, one of:

share increased mobile cellular phone coverage by the two or more mobile cellular UAVs, or

determine whether one deployed mobile cellular UAV may handle the composite load.

10. The system as claimed in claim **6**, wherein said data indicating a convergence or migration of many mobile phone users is based on financial transactions information, said financial transactions data including one or more types of: credit, debit, cash, ATM withdrawals transactions, wherein to determine, said hardware processor is further configured to one or more of:

monitor for occurrence of an increased number of financial transactions of a particular transaction type;

determine if it is a type of transaction that implies said physical convergence or migration; and

determine for a trends or changes in velocity or rate of change of said as compared to a baseline measure; and

in response to a determined trend or change, generate a plan for deploying said one or more mobile cellular UAVs to a roaming pattern to accommodate said destination or directional aspect.

11. The system as claimed in **6**, wherein said data indicating a convergence or migration of many mobile phone users is based on received social media information or conventional media information implying said convergence or migration, said social media network information data including: data from geo-tagged tweets or social media network messages from said user mobile devices, said clustering of group movement prediction being based on said geo-tagged tweets or said social media network messages.

12. The system as claimed in claim **6**, wherein to determine a plan to deploy a mobile cellular unmanned aerial vehicle, said hardware processor is configured to:

configure an autonomic network of mobile cellular UAVs and sending signals to deploy one or more clusters of said mobile cellular UAVs network in a vicinity of or at the area;

detect one or more events indicating a need for new or additional requirements;

update said usage demand map based on said detected events; and

autonomically redeploy or regroup one or more mobile cellular UAVs of a cluster to self correct said autonomic network based on said updated usage demand map.

13. The system as claimed in claim **12**, wherein to autonomically redeploy or regroup one or more mobile cellular UAVs of a cluster, said hardware processor is further configured to:

establish communication among each mobile cellular UAV and a designated leader in the cluster, each said UAV's communicating data according to said updated usage demand map;

monitor that one or more mobile cellular UAVs of said cluster support a particular cell phone usage demand in said area or vicinity according to said updated usage demand map, and

self-correct a capacity of said cluster according to said updated usage demand map.

14. A method for extending cellular phone coverage of a land-based cellular phone network comprising:

receiving, at a hardware processor of a computing device, information for determining a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time;

identifying at said hardware processing device, based on an said predicted or actual increased aggregate cellular phone usage demand for said area, whether there exists a mismatch of existing usage coverage compared with said determined increased aggregate demand for that area;

determining, based on an identified mismatch, a plan for deploying one or more mobile cellular unmanned aerial vehicles (UAV) having telecommunications equipment configured to extend cellular phone network coverage of an existing land-based cellular phone network to the mismatched area; and

sending, by the computing device, a signal to a facility configured to deploy said one or more mobile cellular UAVs to said mismatched area according to said plan,

wherein, responsive to said signal, said one or more mobile cellular UAVs are deployed to said mismatched area to connect with said existing land-based cellular phone network and extend cellular phone usage coverage at said area.

15. The method as claimed in claim **14**, wherein said determining said predicted or actual increase in aggregate cellular phone usage demand includes:

detecting one or more of: incoming signal strengths from mobile phone users received at a fixed land-based cellular phone tower associated with said area, or a number of dropped call events detected from a fixed land-based mobile cellular tower to other fixed land-based mobile cellular towers.

16. The method as claimed in claim **14**, wherein said determining said predicted or actual increase in aggregate cellular phone usage demand includes:

monitoring said cellular phone network land-based fixed cellular phone tower bandwidth and calculating a metric using said monitored fixed cellular phone tower bandwidth divided by a number of registered users.

17. The method as claimed in claim **14**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time, said data including one or more customer requests for increased coverage at said area for a specific time duration, wherein said identifying said area comprises detecting customer requests from one or more of: high profile users, very important customers or customers having a contract with a cellular phone network carrier, emergency responders, or personal calendar events shared voluntarily with a cellular phone network carrier.

18. The method as claimed in claim **14**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time, said method comprising:

predicting clustering of mobile device user group movement from said information; and

generating a usage demand map indicating the predictive clustering of said mobile device user group movement at an area, and

using said usage demand map is used to identify whether one or more areas may need additional coverage during a time of the day.

19. The method as claimed in claim **14**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time, said data comprising: transportation information including one or more of: data representing hired vehicle destination pick-up and drop-off locations, data representing current use of public transportation vehicles; data representing subway tickets sold to mobile phone users, wherein said determining said predicted or actual increase in aggregate cellular phone usage demand further comprises:

analyzing from said received transportation information a location where people are going and a rate of change to that location; and

detecting if a rate of change compared to threshold is achieved that indicates a significant number of people will move in that same direction.

20. The method as claimed in claim **18**, wherein for predicting clustering, sad method further comprises:

detecting a destination of people movement; or

detecting a directional aspect of people movement; and

in response to a destination or directional aspect detecting, generating a plan for deploying said one or more mobile cellular UAVs to a roaming pattern to accommodate said destination or directional aspect; and

sending signals to a facility to deploy and dispatch said one or more mobile cellular UAVs.

21. The method as claimed in claim **20**, wherein signals are sent to a facility according to a plan to deploy and dispatch two or more mobile cellular unmanned aerial vehicles, said method further comprising:

detecting a merging of two or more group movements that provides a composite load to an area;

determining whether said two or more mobile cellular UAVs approach that area; and, one of:

sharing increased mobile cellular phone coverage by the two or more mobile cellular UAVs, or

determining whether one mobile cellular UAVs may handle the composite load.

22. The method as claimed in claim **14**, wherein said data indicating a convergence or migration of many mobile phone users is based on received transportation information including one or more of: data representing received financial transaction information, said financial transactions data including one or more types of: credit, debit, cash, ATM withdrawals transactions, wherein to determine, said hardware processor is further configured to one or more of:

monitor for occurrence of an increased number of financial transactions of a particular transaction type;

determine if it is a type of transaction that implies said physical convergence or migration; and

determine for a trends or changes in velocity or rate of change of said as compared to a baseline measure; and

in response to a determined trend or change, generate a plan for deploying said one or more mobile cellular UAVs to a roaming pattern to accommodate said destination or directional aspect.

23. The method as claimed in **18**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time, said data indicating a convergence or migration of many mobile phone users is based on received social media information or conventional media information implying said convergence or migration, said social media network information data including: data from geo-tagged tweets or social media network messages from said user mobile devices, said predictive clustering of group movement being based on said geo-tagged tweets or said social media network messages.

24. The method as claimed in claim **18**, wherein said deploying according to said generated plan comprises:

configuring an autonomic network of mobile cellular UAVs and sending signals to deploy one or more clusters of said mobile cellular UAVs network in a vicinity of or at the area;

detecting one or more events indicating a need for new or additional requirements;

updating said usage demand map based on said detected events; and

autonomically redeploying or regrouping one or more mobile cellular UAVs of a cluster to self correct said autonomic network based on said updated usage demand map.

25. The method as claimed in claim **24**, wherein said autonomically redeploying or regrouping one or more mobile cellular UAVs of a cluster comprises:

establishing communication among each mobile cellular UAV and a designated leader in the cluster, each said UAV's communicating data according to said updated usage demand map;

monitoring that one or more mobile cellular UAVs of said cluster support a particular cell phone usage demand in said area or vicinity, and

self-correct a capacity of said cluster according to said updated usage demand map.

26. A computer program product for extending cellular phone coverage of a land-based cellular phone network, the computer program product comprising a computer readable storage medium having program instructions embodied therewith, wherein the computer readable storage medium is not a transitory signal per se, the program instructions readable by a processing circuit to cause the processing circuit to perform a method comprising:

receiving information for determining a predicted or actual increase in aggregate cellular phone usage demand in an area at a determined time;

identifying based on an said predicted or actual increased aggregate cellular phone usage demand for said area, whether there exists a mismatch of existing usage coverage compared with said determined increased aggregate demand for that area;

determining, based on an identified mismatch, a plan for deploying one or more mobile cellular unmanned aerial vehicles (UAV) having telecommunications equipment configured to extend cellular phone network coverage of an existing land-based cellular phone network to the mismatched area; and

sending, by the computing device, a signal to a facility configured to deploy said one or more mobile cellular UAVs to said mismatched area according to said plan,

wherein, responsive to said signal, said one or more mobile cellular UAVs are deployed to said mismatched area to connect with said existing land-based cellular phone network and extend cellular phone usage coverage at said area.

27. The computer program product as claimed in claim **26**, wherein said information includes data indicating a convergence or migration of many mobile phone users to said identified area at a current or future time, said method comprising:

predicting clustering of mobile device user group movement from said information; and

generating a usage demand map indicating the predictive clustering of said mobile device user group movement at an area, and

using said usage demand map is used to identify whether one or more areas may need additional coverage during a time of the day.

28. The computer program product as claimed in claim **26**, wherein to predict clustering, said method further comprises:

detecting a destination of people movement; or

detecting a directional aspect of people movement; and

in response to a destination or directional aspect detection, generating a plan for deploying said one or more mobile cellular UAVs to a roaming pattern to accommodate said destination or directional aspect; and

sending signals to a facility to deploy and dispatch said one or more mobile cellular UAVs.

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