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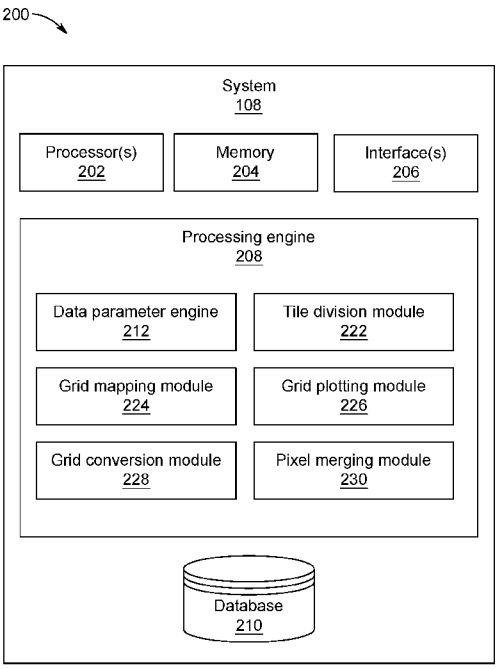

FIG. 2

(57) Abstract: A system (108) and method (300) for visualizing coverage data using grid-to-tile conversion is disclosed. The system (108) is configured to divide, by a tile division module of a processing engine (208), a map of an area into a plurality of tiles, each tile representing a defined area. A grid area within a tile is mapped, by the processing engine (208), to its corresponding parent tile. The system (108) then plots, by the processing engine (208), the position of each grid within the corresponding parent tile. Each grid is converted, by the processing engine (208), to a pixel with a specific color based on a key performance indicator (KPI) value. The pixels for each corresponding tile are merged, by a pixel merging module (230) of the processing engine (208), and the merged pixels are saved as an image representing the coverage data.

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SYSTEM AND METHOD FOR VISUALIZATION OF COVERAGE DATA

RESERVATION OF RIGHTS

FIELD OF INVENTION

[0002] The present disclosure generally relates to communication technology. More particularly, the present disclosure relates to a system and a method for visualization of coverage data using grid to tile conversion.

BACKGROUND OF THE INVENTION

[0003] The following description of the related art is intended to provide background information pertaining to the field of the disclosure. This section may include certain aspects of the art that may be related to various features of the present disclosure. However, it should be appreciated that this section is used only to enhance the understanding of the reader with respect to the present disclosure, and not as admission of the prior art.

[0004] In the field of telecommunications, network coverage plays a crucial role in ensuring reliable and high-quality service for users. With the widespread deployment of mobile networks across PAN India, network operators face the

challenge of efficiently managing and analyzing the vast amount of coverage data generated by their networks. This data includes various Key Performance Indicators (KPIs) such as RSRP (Reference Signal Received Power), SINR (Signal-to-Interference-plus-Noise Ratio), and DL (Downlink) Throughput.

[0005] Traditionally, analyzing network coverage required extensive field visits and manual data collection, which was time-consuming, expensive, and often impractical due to the scale of the network. However, with advancements in technology and the availability of crowdsourced measurement data, a more efficient and cost-effective approach has emerged.

[0006] There is, therefore, a need in the art to provide a method and a system that can overcome the shortcomings of the existing prior arts.

OBJECTS OF THE PRESENT DISCLOSURE

[0007] Some of the objects of the present disclosure, which at least one embodiment herein satisfies are as listed herein below.

[0008] An object of the present disclosure is to provide a system and a method for visualization of coverage data with a user interface (UI) that allows users to view and analyze Key Performance Indicators (KPIs) related to network coverage in a Pan India network.

[0009] An object of the present disclosure is to provide a system and a method for visualization of coverage data incorporating a crowdsourced measurement data collection module collecting measurement data from user devices for evaluating network coverage and performance across Pan India.

[0010] An object of the present disclosure is to provide a system and a method for visualization of coverage data by combining the crowdsourced measurement data with the prediction data to generate a continuous coverage layer representing the network's performance.

[0011] An object of the present disclosure is to provide a system and a method for visualization of coverage data by plotting grid positions to provide a reference for each position's location on the coverage layer and pinpoint specific areas of interest for analysis and optimization.

[0012] An object of the present disclosure is to provide a system and a method for visualization of coverage data by converting grid positions to pixels on an image and assigning specific colors to each pixel based on the corresponding KPI value.

SUMMARY

[0013] The present disclosure discloses a system for visualizing coverage data using grid-to-tile conversion, said system configured to divide, by a tile division module of a processing engine, a map of an area into a plurality of tiles, each tile representing an area, map, by a grid mapping module of the processing engine, a grid area within a tile to its corresponding parent tile, plot, by a grid plotting module of the processing engine, position of each grid within the corresponding parent tile, convert, by a grid conversion module of the processing engine, each grid to a pixel with a specific color based on a key performance indicator (KPI) value and merge, by a pixel merging module of the processing engine, pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

[0014] In an embodiment, the system is further configured to augment a crowdsourced measurement data with a prediction data to generate a continuous coverage layer at a 5x5 meter granularity for key network KPIs, including RSRP, SINR, and DL Throughput.

[0015] In an embodiment, the KPIs are visualized using custom legends and ranges to enable different ranges and colors for the selected KPI as per use case.

[0016] In an embodiment, the saved image representing the coverage data enables planning and optimization teams to analyze coverage issues in specific areas without any field visit.

[0017] In an embodiment, the system further comprises a user interface module configured to allow an end user to apply different ranges and colors for the selected KPI as per the use case.

[0018] The present disclosure discloses a method for visualizing coverage data using grid-to-tile conversion, said method comprising of dividing, by a tile division module of a processing engine, a map of an area into a plurality of tiles, each tile representing an area, mapping, by a grid mapping module of the processing engine, a grid area within a tile to its corresponding parent tile, plotting, by a grid plotting module of the processing engine, a position of each grid within the corresponding parent tile, converting, by a grid conversion module of the processing engine, each grid to a pixel with a specific color based on a key performance indicator (KPI) value and merging, by a pixel merging module of the processing engine, pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

[0019] The present disclosure discloses computer program product comprising a non-transitory computer-readable medium comprising instructions that, when executed by one or more processors, cause the one or more processors to divide, by a tile division module of a processing engine, a map of an area into a plurality of tiles, each tile representing an area, map, by a grid mapping module of the processing engine, a grid area within a tile to its corresponding parent tile, plot, by a grid plotting module of the processing engine, position of each grid within the corresponding parent tile, convert, by a grid conversion module of the processing engine, each grid to a pixel with a specific color based on a key performance indicator (KPI) value and merge, by a pixel merging module of the processing engine, pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

[0020] The present disclosure discloses a user equipment configured to divide, by a tile division module of a processing engine, a map of an area into a plurality of tiles, each tile representing an area, mapping, by a grid mapping module of the processing engine, a grid area within a tile to its corresponding parent tile, plotting, by a grid plotting module of the processing engine, a position of each grid within the corresponding parent tile, converting, by a grid conversion module of the processing engine, each grid to a pixel with a specific color based on a key performance indicator (KPI) value and merging, by a pixel merging module of the processing engine, pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data

LIST OF REFERENCE NUMERALS

100 – Network Architecture

1 102-1, 102-2…102-N – Users

104-1, 104-2…104-N – User Equipments (UEs)

106 – Network

108 – System

110 – Entity

112 – Centralized Server

200: Block diagram of the system for visualizing coverage data using grid-to-tile conversion

202- Processor(s) of the system for visualizing coverage data

204- Memory of the system for visualizing coverage data

206- Interface(s) of the system for visualizing coverage data

208- Processing engine(s) of the system for visualizing coverage data

210- Database

212- Data parameter engine

222- Tile division module

224- Grid mapping module

226- Grid plotting module

228- Grid conversion module

230- Pixel merging module

500 – Example computer system

510 – External storage device

520 – Bus

530 – Main memory

540 – Read-only memory

550 – Mass storage device

560 – Communication port(s)

570 – Processor

BRIEF DESCRIPTION OF DRAWINGS

[0021] The accompanying drawings, which are incorporated herein, and constitute a part of this disclosure, illustrate exemplary embodiments of the disclosed methods and systems which like reference numerals refer to the same parts throughout the different drawings. Components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Some drawings may indicate the components using block diagrams and may not represent the internal circuitry of each component. It will be appreciated by those skilled in the art that disclosure of such drawings includes the disclosure of electrical components, electronic components, or circuitry commonly used to implement such components.

[0022] FIG. 1 illustrates an example network architecture for implementing a proposed system, in accordance with an embodiment of the present disclosure.

[0023] FIG. 2 illustrates an example block diagram of a proposed system (108), in accordance with an embodiment of the present disclosure.

[0024] FIG. 3 illustrates an example flow diagram for visualization of coverage data using grid to tile conversion, in accordance with an embodiment of the present disclosure.

[0025] FIG. 4A illustrates a map of India showing the coverage data across the country, in accordance with an embodiment of the present disclosure.

[0026] FIG. 4B provides a more detailed view of the coverage data for a specific region, in accordance with an embodiment of the present disclosure.

[0027] FIG. 4C shows a legend indicating the RSRP (Reference Signal Received Power) values in dBm (decibels relative to one milliwatt), in accordance with an embodiment of the present disclosure.

[0028] FIG. 4D illustrates the custom legends and ranges functionality of the user interface module, in accordance with an embodiment of the present disclosure.

[0029] FIG. 5 illustrates an example computer system in which or with which the embodiments of the present disclosure may be implemented.

[0030] The foregoing shall be more apparent from the following more detailed description of the disclosure.

DETAILED DESCRIPTION

[0031] In the following description, for explanation, various specific details are outlined in order to provide a thorough understanding of embodiments of the present disclosure. It will be apparent, however, that embodiments of the present disclosure may be practiced without these specific details. Several features described hereafter can each be used independently of one another or with any combination of other features. An individual feature may not address all of the problems discussed above or might address only some of the problems discussed above. Some of the problems discussed above might not be fully addressed by any of the features described herein.

[0032] The ensuing description provides exemplary embodiments only and is not intended to limit the scope, applicability, or configuration of the disclosure.

Rather, the ensuing description of the exemplary embodiments will provide those skilled in the art with an enabling description for implementing an exemplary embodiment. It should be understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the disclosure as set forth.

[0033] Specific details are given in the following description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, circuits, systems, networks, processes, and other components may be shown as components in block diagram form in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail to avoid obscuring the embodiments.

[0034] Also, it is noted that individual embodiments may be described as a process that is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed but could have additional steps not included in a figure. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination can correspond to a return of the function to the calling function or the main function.

[0035] The word “exemplary” and/or “demonstrative” is used herein to mean serving as an example, instance, or illustration. For the avoidance of doubt, the subject matter disclosed herein is not limited by such examples. In addition, any aspect or design described herein as “exemplary” and/or “demonstrative” is not necessarily to be construed as preferred or advantageous over other aspects or designs, nor is it meant to preclude equivalent exemplary structures and techniques

known to those of ordinary skill in the art. Furthermore, to the extent that the terms "includes," "has," "contains," and other similar words are used in either the detailed description or the claims, such terms are intended to be inclusive like the term "comprising" as an open transition word without precluding any additional or other elements.

[0036] Reference throughout this specification to "one embodiment" or "an embodiment" or "an instance" or "one instance" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0037] The terminology used herein is to describe particular embodiments only and is not intended to be limiting the disclosure. As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any combinations of one or more of the associated listed items.

[0038] The present disclosure relates to a system and method for visualizing coverage data using grid-to-tile conversion. The system is designed to help planning and optimization teams analyze network performance efficiently without extensive field visits.

[0039] The system divides a map into an area of tiles using a tile division module. Each tile is further divided into a grid area, where each tile may be mapped

to its parent tiles by a grid mapping module. A grid plotting module determines the exact positions of these grids within the parent tiles. The grid conversion module then assigns a specific color to each grid based on key performance indicator (KPI) values such as Reference Signal Received Power (RSRP), Signal-to-Interference-plus-Noise Ratio (SINR), and Downlink (DL) throughput. These colored pixels are merged to a corresponding tile by a pixel merging module, and the final image is saved by a storage module for analysis.

[0040] The method for visualizing coverage data involves dividing the map into 50x50 meter tiles, mapping each 5x5 meter grid to its parent tile, plotting the position of each grid within the parent tile, converting each grid to a pixel with a color based on KPI values, and merging the pixels to corresponding tile for each tile to save the image.

[0041] The system includes a data augmentation module to enhance coverage data accuracy by combining crowdsourced measurement data with prediction data at a 5x5 meter granularity. A user interface module allows users to apply custom legends and ranges for KPIs, facilitating tailored visualizations.

[0042] The various embodiments throughout the disclosure will be explained in more detail with reference to FIGS. 1-5.

[0043] FIG. 1 illustrates an exemplary network architecture in which or with which a system (108) for managing a plurality of stale sessions in a wireless network is implemented, in accordance with embodiments of the present disclosure.

[0044] Referring to FIG. 1, the network architecture (100) includes one or more computing devices or user equipments (104-1, 104-2…104-N) associated with one or more users (102-1, 102-2…102-N) in an environment. A person of ordinary skill in the art will understand that one or more users (102-1, 102-2…102-N) may be individually referred to as the user (102) and collectively referred to as the users (102). Similarly, a person of ordinary skill in the art will understand that one or more user equipments (104-1, 104-2…104-N) may be individually referred

to as the user equipment (104) and collectively referred to as the user equipment (104). A person of ordinary skill in the art will appreciate that the terms "computing device(s)" and "user equipment" may be used interchangeably throughout the disclosure. Although three user equipments (104) are depicted in FIG. 1, however any number of the user equipments (104) may be included without departing from the scope of the ongoing description.

[0045] In an embodiment, the user equipment (104) includes smart devices operating in a smart environment, for example, an Internet of Things (IoT) system. In such an embodiment, the user equipment (104) may include, but is not limited to, smart phones, smart watches, smart sensors (e.g., mechanical, thermal, electrical, magnetic, etc.), networked appliances, networked peripheral devices, networked lighting system, communication devices, networked vehicle accessories, networked vehicular devices, smart accessories, tablets, smart television (TV), computers, smart security system, smart home system, other devices for monitoring or interacting with or for the users (102) and/or entities, or any combination thereof. A person of ordinary skill in the art will appreciate that the user equipment (104) may include, but is not limited to, intelligent, multi-sensing, network-connected devices, that can integrate seamlessly with each other and/or with a central server or a cloud-computing system or any other device that is network-connected.

[0046] In an embodiment, the user equipment (104) includes, but is not limited to, a handheld wireless communication device (e.g., a mobile phone, a smart phone, a phablet device, and so on), a wearable computer device(e.g., a head-mounted display computer device, a head-mounted camera device, a wristwatch computer device, and so on), a Global Positioning System (GPS) device, a laptop computer, a tablet computer, or another type of portable computer, a media playing device, a portable gaming system, and/or any other type of computer device with wireless communication capabilities, and the like. In an embodiment, the user equipment (104) includes, but is not limited to, any electrical, electronic, electro-mechanical, or an equipment, or a combination of one or more of the above devices such as virtual reality (VR) devices, augmented reality (AR) devices, laptop, a

general-purpose computer, desktop, personal digital assistant, tablet computer, mainframe computer, or any other computing device, wherein the user equipment (104) may include one or more in-built or externally coupled accessories including, but not limited to, a visual aid device such as a camera, an audio aid, a microphone, a keyboard, and input devices for receiving input from the user (102), or the entity (110) such as touch pad, touch enabled screen, electronic pen, and the like. A person of ordinary skill in the art will appreciate that the user equipment (104) may not be restricted to the mentioned devices and various other devices may be used.

[0047] Referring to FIG. 1, the user equipment (104) communicates with a system (108), for example, a stale session management system, through a network (106). In an embodiment, the network (106) includes at least one of a Fifth Generation (5G) network, Sixth Generation (6G) network, or the like advanced network generations. The network (106) enables the user equipment (104) to communicate with other devices in the network architecture (100) and/or with the system (108). The network (106) includes a wireless card or some other transceiver connection to facilitate this communication. In another embodiment, the network (106) is implemented as, or include any of a variety of different communication technologies such as a wide area network (WAN), a local area network (LAN), a wireless network, a mobile network, a Virtual Private Network (VPN), the Internet, the Public Switched Telephone Network (PSTN), or the like.

[0048] In another exemplary embodiment, the centralized server (112) includes or comprise, by way of example but not limitation, one or more of: a stand-alone server, a server blade, a server rack, a bank of servers, a server farm, hardware supporting a part of a cloud service or system, a home server, hardware running a virtualized server, one or more processors executing code to function as a server, one or more machines performing server-side functionality as described herein, at least a portion of any of the above, some combination thereof.

[0049] In an embodiment, the system (108) may combine a received set of crowdsource measurement data with the generated set of predictions to generate a continuous coverage layer.

[0050] In an embodiment, the system (108) may divide the map into tiles of configurable value and map a grid to its parent tile.

[0051] In an embodiment, the system (108) may tag the grid position in the tagged parent tile.

[0052] In an embodiment, the system (108) may convert the grid position to a pixel with a specific color based on the KPI value.

[0053] In an embodiment, the system (108) may merge pixels for corresponding tiles and save the merged pixels as an image.

[0054] In an embodiment, the system (108) may enable the one or more users (102) to apply different ranges and colors for selected KPIs.

[0055] FIG. 2 illustrates an example block diagram (200) of a proposed system (108), in accordance with an embodiment of the present disclosure.

[0056] Referring to FIG. 2, in an embodiment, the system (108) may include one or more processor(s) (202). The one or more processor(s) (202) may be implemented as one or more microprocessors, microcomputers, microcontrollers, digital signal processors, central processing units, logic circuitries, and/or any devices that process data based on operational instructions. Among other capabilities, the one or more processor(s) (202) may be configured to fetch and execute computer-readable instructions stored in a memory (204) of the system (108). The memory (204) may be configured to store one or more computer-readable instructions or routines in a non-transitory computer readable storage medium, which may be fetched and executed to create or share data packets over a network service. The memory (204) may comprise any non-transitory storage device including, for example, volatile memory such as random-access memory

(RAM), or non-volatile memory such as erasable programmable read only memory (EPROM), flash memory, and the like.

[0057] In an embodiment, the system (108) may include an interface(s) (206). The interface(s) (206) may comprise a variety of interfaces, for example, interfaces for data input and output devices (I/O), storage devices, and the like. The interface(s) (206) may facilitate communication through the system (108). The interface(s) (206) may also provide a communication pathway for one or more components of the system (108). Examples of such components include, but are not limited to, processing engine(s) (208) and a database (210). Further, the processing engine(s) (208) may include a data parameter engine (212) and other engine(s). In an embodiment, the other engine(s) may include, but not limited to, a data ingestion engine, an input/output engine, and a notification engine.

[0058] In an embodiment, the processing engine(s) (208) may be implemented as a combination of hardware and programming (for example, programmable instructions) to implement one or more functionalities of the processing engine(s) (208). In examples described herein, such combinations of hardware and programming may be implemented in several different ways. For example, the programming for the processing engine(s) (208) may be processor-executable instructions stored on a non-transitory machine-readable storage medium and the hardware for the processing engine(s) (208) may comprise a processing resource (for example, one or more processors), to execute such instructions. In the present examples, the machine-readable storage medium may store instructions that, when executed by the processing resource, implement the processing engine(s) (208). In such examples, the system may comprise the machine-readable storage medium storing the instructions and the processing resource to execute the instructions, or the machine-readable storage medium may be separate but accessible to the system and the processing resource. In other examples, the processing engine(s) (208) may be implemented by electronic circuitry.

[0059] In an embodiment, the processor (202) may receive a set of measurement data via the data parameter engine (212). The set of measurement data may be received from the one or more computing devices (104) associated with the one or more users (104). The processor (202) may store the measurement in the database (210). The processor (202) may view and analyze a set of Key Performance Indictors (KPIs) of a network coverage in a PAN India network. The system (202) may generate a set of predictions for the set of KPIs at a configurable granularity.

[0060] The memory (204) is configured to store computer-readable instructions or routines in a non-transitory computer-readable storage medium, which may be fetched and executed to perform various functions of the system (108). The memory (204) may include volatile memory such as random-access memory (RAM) or non-volatile memory such as erasable programmable read-only memory (EPROM), flash memory, and the like. For instance, the memory (204) may store the instructions for grid-to-tile conversion, KPI mapping, and image saving.

[0061] The interface(s) (206) may comprise a variety of interfaces, such as interfaces for data input and output devices (I/O), storage devices, and the like. The interface(s) (206) facilitate communication through the system (108) and provide a communication pathway for the components of the system (108). For example, the interface(s) (206) may enable the system (108) to receive crowdsourced measurement data and prediction data from external sources.

[0062] The system (108) further includes processing engine(s) (208) which may comprise a tile division module (222), a grid mapping module (224), a grid plotting module (226), a grid conversion module (228), a pixel merging module (230), and a storage module. The processing engine(s) (208) may be implemented as a combination of hardware and programming to perform the functions described below.

[0063] The tile division module (222) of the processing engine (208) is configured to divide a map of an area into a plurality of tiles, each tile may represent a 50x50 meter area or any other dimension as per requirement since the title can be of any shape such as geometric shape (for example, square, hexagon, etc.). These initial tiles for example define a subarea of the area i.e., 50x50 meter area act as parent tiles. For example, the map may be divided into multiple tiles to facilitate detailed coverage analysis. This division allows the system (108) to handle large datasets by breaking them down into manageable sections.

[0064] The grid mapping module (224) of the processing engine (208) maps each 5x5 meter grid within a tile to its corresponding parent tile. For instance, within each 50x50 meter tile, there are 100 grids of 5x5 meters each, which are mapped to their parent tile to maintain hierarchical spatial data. This hierarchical mapping ensures that the data is organized efficiently and can be accessed quickly for further processing. Each parent tile is then further divided into smaller grids by the grid mapping module (224).

[0065] Since each grid resides within a specific parent tile, identifying the parent tile for a particular grid involves understanding its location within the overall map. In an embodiment, the system (108) may employ a spatial mapping mechanism to achieve this. For example:

- Each parent tile may be assigned a unique identifier or reference.
- The location of each grid within the parent tile (determined by its 5x5 meter position) may be encoded using a specific coordinate system relative to the parent tile's origin (top-left corner).
- By combining the parent tile identification with the grid's relative location within that tile, the system (108) may be configured to identify grid position in the corresponding parent tile.

[0066] The grid plotting module (226) of the processing engine (208) plots the position of each grid within the corresponding parent tile. This involves determining the exact location of each 5x5 meter grid within the 50x50 meter tile.

By plotting these positions accurately, the system (108) can create a precise representation of the coverage data.

[0067] The grid conversion module (228) of the processing engine (208) converts each grid to a pixel with a specific color based on a KPI value from the set of KPIs. For example, a grid with a high RSRP value may be converted to a green pixel, while a grid with a low RSRP value may be converted to a red pixel. This color-coding based on KPI values allows for easy visualization and interpretation of the data.

[0068] The pixel merging module (230) of the processing engine (208) merges pixels for each corresponding tile. This step involves merging all the colored pixels to a corresponding tile to create a coherent image that represents the coverage data for that tile. The merging process ensures that the final image is a comprehensive representation of the coverage data, showing variations in coverage across the area.

[0069] The storage module of the processing engine (208) saves the merged pixels as an image representing the coverage data. This image can be used for visual analysis and reporting. By saving the data as an image, the system (108) provides a user-friendly format for further analysis and decision-making.

[0070] In an embodiment, the system (108) may also include a data augmentation module configured to augment crowdsourced measurement data with prediction data to generate a continuous coverage layer at a 5x5 meter granularity for key network KPIs, including RSRP, SINR, and DL Throughput. For example, crowdsourced data from the user equipment (104) may be combined with network predictions to create a detailed and continuous coverage map. This augmentation enhances the accuracy and completeness of the coverage data.

[0071] Additionally, the system (108) may include a user interface module (206) that may allow the user (102) to apply different ranges and colors for the selected KPI as per use case, providing custom legends and ranges to visualize the

KPIs effectively. For example, the user (102) can customize the color range for SINR values to better interpret the data according to their requirements. This customization capability allows users to tailor the visualization to their specific needs, improving the utility of the data.

[0072] In an embodiment, the legend is a visual key within the image that associates different colors with selected KPI value.

[0073] KPI values typically represent signal strength, signal-to-noise ratio, or throughput. These values can range from low to high. In an embodiment, custom ranges allow the user (102) to define the specific range of KPI values they want to represent using a particular color in the legend.

[0074] The system (108) enables planning and optimization teams to analyze coverage issues in specific areas without any field visit by visualizing the saved image representing the coverage data. This visualization assists in generating various coverage analytics modules such as coverage hole identification and coverage analysis reports. For instance, an optimization team can identify coverage gaps in urban areas by analyzing the visualized coverage data. By providing a clear and detailed view of the coverage data, the system (108) supports effective network planning and optimization.

[0075] Although FIG. 2 shows exemplary components of the system (108), in other embodiments, the system (108) may include fewer components, different components, differently arranged components, or additional functional components than depicted in FIG. 2. Additionally, or alternatively, one or more components of the system (108) may perform functions described as being performed by one or more other components of the system (108). For example, the system (108) might include additional modules for handling more complex data processing tasks or integrating with other network management systems.

[0076] FIG. 3 illustrates an example flow diagram (300) for visualization of coverage data using grid-to-tile conversion, in accordance with an embodiment of

the present disclosure. As illustrated in FIG. 3, the following steps may be implemented by the system (108) for the visualization of coverage data using grid-to-tile conversion.

[0077] At step 302, the system (108) may divide the map into tiles of 50m x 50m. This step involves breaking down the entire map of India into smaller, more manageable sections called tiles. Each tile represents a 50x50 meter area, allowing the system to process and analyze coverage data in smaller segments rather than dealing with the entire map at once. This tiling process helps in organizing the data spatially and makes subsequent processing steps more efficient.

[0078] At step 304, the system (108) may map the 5m x 5m grid to the parent tile. Within each 50x50 meter tile, the system further divides the area into smaller grids, each measuring 5x5 meters. These smaller grids are then mapped to their corresponding parent tile. This hierarchical mapping helps in maintaining the spatial relationship between the grids and the tiles, ensuring that each grid is accurately located within its larger tile. For example, a grid located at coordinates (10, 10) within a tile is mapped precisely to that tile's position in the overall map.

[0079] At step 306, the system (108) may plot grid positions in the tagged parent tile. In this step, the exact position of each 5x5 meter grid is determined and plotted within the corresponding 50x50 meter parent tile. This involves tagging each grid with its coordinates and ensuring that it is accurately placed within the parent tile. The plotting process creates a detailed spatial representation of all grids within each tile, which is essential for accurate data visualization.

[0080] At step 308, the system (108) may convert the grid to a pixel with a specific color based on a KPI value from a set of KPIs. Each grid is assigned a color based on the value of the KPI value from the set of KPIs, such as RSRP, SINR, or DL Throughput. For instance, a grid with a high RSRP value may be converted to a green pixel, indicating strong signal strength, while a grid with a low RSRP value may be converted to a red pixel, indicating weak signal strength. This color-coding makes it easy to visualize and interpret the KPI values across different regions.

[0081] At step 310, the system (108) may merge the pixels for the corresponding tile and save the merged pixels as an image. In this final step, all the colored pixels within each tile are combined to create a coherent image that represents the coverage data for that tile. The merged image provides a visual summary of the KPI values across the entire tile. The system then saves this image for further analysis and reporting. This image can be used by planning and optimization teams to identify coverage issues, generate reports, and make informed decisions about network improvements.

[0082] FIG. 4A illustrates a map of India showing the coverage data across the country. The map is divided into multiple tiles, each representing a 50x50 meter area. Different colors on the map represent varying levels of coverage, indicating the strength and quality of the network in different regions. For example, areas with strong coverage may be shown in blue, while areas with weaker coverage may be shown in red.

[0083] FIG. 4B provides a more detailed view of the coverage data for a specific region. This zoomed-in view shows the coverage data at a finer granularity, allowing users to see the variations in network performance at a more localized level. The color gradient, ranging from green to red, indicates the strength of the signal, with green representing strong coverage and red representing weak coverage.

[0084] FIG. 4C shows a legend indicating the RSRP (Reference Signal Received Power) values in dBm (decibels relative to one milliwatt). The legend uses a color gradient to represent different ranges of RSRP values. For example, values from -140 dBm to -113 dBm are shown in red, values from -105 dBm to -100 dBm are shown in orange, values from -95 dBm to -90 dBm are shown in green, and values from -90 dBm to -40 dBm are shown in blue. This legend helps users to easily interpret the coverage data visualized on the map.

[0085] FIG. 4D illustrates the custom legends and ranges functionality of the user interface module. Users can define custom ranges and assign specific colors

to these ranges based on their use case. For instance, in this example, three ranges are defined:

Range 1: -100 dBm to -40 dBm, shown in blue.
Range 2: -120 dBm to -100 dBm, shown in light blue.
Range 3: -140 dBm to -120 dBm, shown in red.

[0086] This customization capability allows users to tailor the visualization according to their specific requirements, making it easier to analyze and interpret the coverage data.

[0087] By utilizing these custom legends and ranges, the system (108) provides a flexible and user-friendly way to visualize coverage data, helping planning and optimization teams to identify and address network issues more effectively.

[0088] FIG. 5 illustrates an example computer system (500) in which or with which the embodiments of the present disclosure may be implemented.

[0089] As shown in FIG. 5, the computer system (500) may include an external storage device (510), a bus (520), a main memory (530), a read-only memory (540), a mass storage device (550), a communication port(s) (560), and a processor (570). A person skilled in the art will appreciate that the computer system (500) may include more than one processor and communication ports. The processor (570) may include various modules associated with embodiments of the present disclosure. The communication port(s) (560) may be any of an RS-232 port for use with a modem-based dialup connection, a 10/100 Ethernet port, a Gigabit or 10 Gigabit port using copper or fiber, a serial port, a parallel port, or other existing or future ports. The communication ports(s) (560) may be chosen depending on a network, such as a Local Area Network (LAN), Wide Area Network (WAN), or any network to which the computer system (500) connects.

[0090] In an embodiment, the main memory (530) may be Random Access Memory (RAM), or any other dynamic storage device commonly known in the art.

The read-only memory (540) may be any static storage device(s) e.g., but not limited to, a Programmable Read Only Memory (PROM) chip for storing static information e.g., start-up or basic input/output system (BIOS) instructions for the processor (570). The mass storage device (550) may be any current or future mass storage solution, which can be used to store information and/or instructions. Exemplary mass storage solutions include, but are not limited to, Parallel Advanced Technology Attachment (PATA) or Serial Advanced Technology Attachment (SATA) hard disk drives or solid-state drives (internal or external, e.g., having Universal Serial Bus (USB) and/or Firewire interfaces).

[0091] In an embodiment, the bus (520) may communicatively couple the processor(s) (570) with the other memory, storage, and communication blocks. The bus (520) may be, e.g. a Peripheral Component Interconnect PCI) / PCI Extended (PCI-X) bus, Small Computer System Interface (SCSI), Universal Serial Bus (USB), or the like, for connecting expansion cards, drives, and other subsystems as well as other buses, such a front side bus (FSB), which connects the processor (570) to the computer system (500).

[0092] In another embodiment, operator and administrative interfaces, e.g., a display, keyboard, and cursor control device may also be coupled to the bus (520) to support direct operator interaction with the computer system (500). Other operator and administrative interfaces can be provided through network connections connected through the communication port(s) (560). The components described above are meant only to exemplify various possibilities. In no way should the aforementioned exemplary computer system (500) limit the scope of the present disclosure.

[0093] While considerable emphasis has been placed herein on the preferred embodiments, it will be appreciated that many embodiments can be made and that many changes can be made in the preferred embodiments without departing from the principles of the disclosure. These and other changes in the preferred embodiments of the disclosure will be apparent to those skilled in the art from the

disclosure herein, whereby it is to be distinctly understood that the foregoing descriptive matter is to be implemented merely as illustrative of the disclosure and not as a limitation.

ADVANTAGES OF THE INVENTION

[0094] The present disclosure provides a system and a method for visualization of coverage data that allow users to view and analyze Key Performance Indicators (KPIs) related to network coverage and access and interpret the coverage data efficiently.

[0095] The present disclosure provides a system and a method for visualization of coverage data that collects measurement data from user devices for evaluating network coverage and performance across PAN India.

[0096] The present disclosure provides a system and a method for visualization of coverage data that combines the crowdsourced measurement data with the prediction data to generate a continuous coverage layer to accurately represent the network's performance across an area.

[0097] The present disclosure provides a system and a method for visualization of coverage data utilizing grid to tile conversion for precise positioning and tagging of grid positions within each tile.

[0098] The present disclosure provides a system and a method for visualization of coverage data by providing a reference for each position's location on the coverage layer to enable users to pinpoint specific areas of interest for analysis and optimization.

CLAIMS

We Claim:

1. A system (108) for visualizing coverage data using grid-to-tile conversion, said system (108) configured to:

divide, by a tile division module (222) of a processing engine (208), a map of an area into a plurality of parent tiles, each tile defining a pre-defined subarea;

map, by a grid mapping module (224) of the processing engine (208), a grid area within a tile to its corresponding parent tile, wherein the grid area is a portion of the corresponding parent tile;

plot, by a grid plotting module (226) of the processing engine (208), position of each grid within the corresponding parent tile;

convert, by a grid conversion module (228) of the processing engine (208), each grid to a pixel with a specific color based on a key performance indicator (KPI) value; and

merge, by a pixel merging module (230) of the processing engine (208), pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

2. The system (108), as claimed in claim 1, is further configured to augment crowdsourced measurement data with prediction data to generate a continuous coverage layer at a 5x5 meter granularity for key network KPIs, including Reference Signal Received Power (RSRP), Signal-to-Interference-plus-Noise Ratio (SINR), and Downlink (DL) throughput.

3. The system (108) as claimed in claim 1, wherein the KPI value is visualized using custom legends and ranges to enable different ranges and colors for the selected KPI.

4. The system (108) as claimed in claim 1, wherein the saved image representing the coverage data enables planning and optimization teams to analyze coverage issues in specific areas without any field visit.

5. The system (108) as claimed in claim 1, further comprising a user interface module configured to allow an end user to apply different ranges and colors for the selected KPI.

6. A method (300) for visualizing coverage data using grid-to-tile conversion, said method (300) comprising:

dividing (302), by a tile division module of a processing engine (208), a map of an area into a plurality of parent tiles, each tile representing a pre-defined area;

mapping (304), by a grid mapping module (224) (224) of the processing engine (208), a grid area within a tile to its corresponding parent tile, wherein the grid area is a portion of the corresponding parent tile;;

plotting (306), by a grid plotting module (226) of the processing engine (208), a position of each grid within the corresponding parent tile;

converting (308), by a grid conversion module (228) of the processing engine (208), each grid to a pixel with a specific color based on a key performance indicator (KPI) value; and

merging (310), by a pixel merging module (230) of the processing engine (208), pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

7. The method (300) as claimed in claim 6, further comprising augmenting, by a data augmentation module, crowdsourced measurement data with prediction data to generate a continuous coverage layer at a 5x5 meter granularity for key network KPIs, including Reference Signal Received

Power (RSRP), Signal-to-Interference-plus-Noise Ratio (SINR), and Downlink (DL) throughput.

8. The method (300) as claimed in claim 6, wherein the KPIs are visualized using custom legends and ranges to enable different ranges and colors for the selected KPI.

9. The method (300) as claimed in claim 6, wherein the saved image representing the coverage data enables planning and optimization teams to analyze coverage issues in specific areas without any field visit.

10. The method (300) as claimed in claim 6, further comprising enabling, by a user interface module, an end user to apply different ranges and colors for the selected KPI.

11. A computer program product comprising a non-transitory computer-readable medium comprising instructions that, when executed by one or more processors, cause the one or more processors to:

divide, by a tile division module of a processing engine (208), a map of an area into a plurality of parent tiles, each tile representing a pre-defined subarea area;

map, by a grid mapping module (224) of the processing engine (208), a grid area within a tile to its corresponding parent tile, wherein the grid area is a portion of the corresponding parent tile;

plot, by a grid plotting module (226) of the processing engine (208), a position of each grid within the corresponding parent tile;

convert, by a grid conversion module (228) of the processing engine (208), each grid to a pixel with a specific color based on a key performance indicator (KPI) value; and

merge, by a pixel merging module (230) of the processing engine (208), pixels for each corresponding tile, wherein the merged pixels are saved as an image representing the coverage data.

12. A user equipment (104) communicatively coupled with a system (108), the coupling comprises steps of:

receiving a connection request from the system (108);

sending an acknowledgment of the connection request to the system (108);

transmitting a plurality of signals in response to the connection request, wherein the system (108) is configured for visualizing coverage data using grid-to-tile conversion as claimed in claim 1.

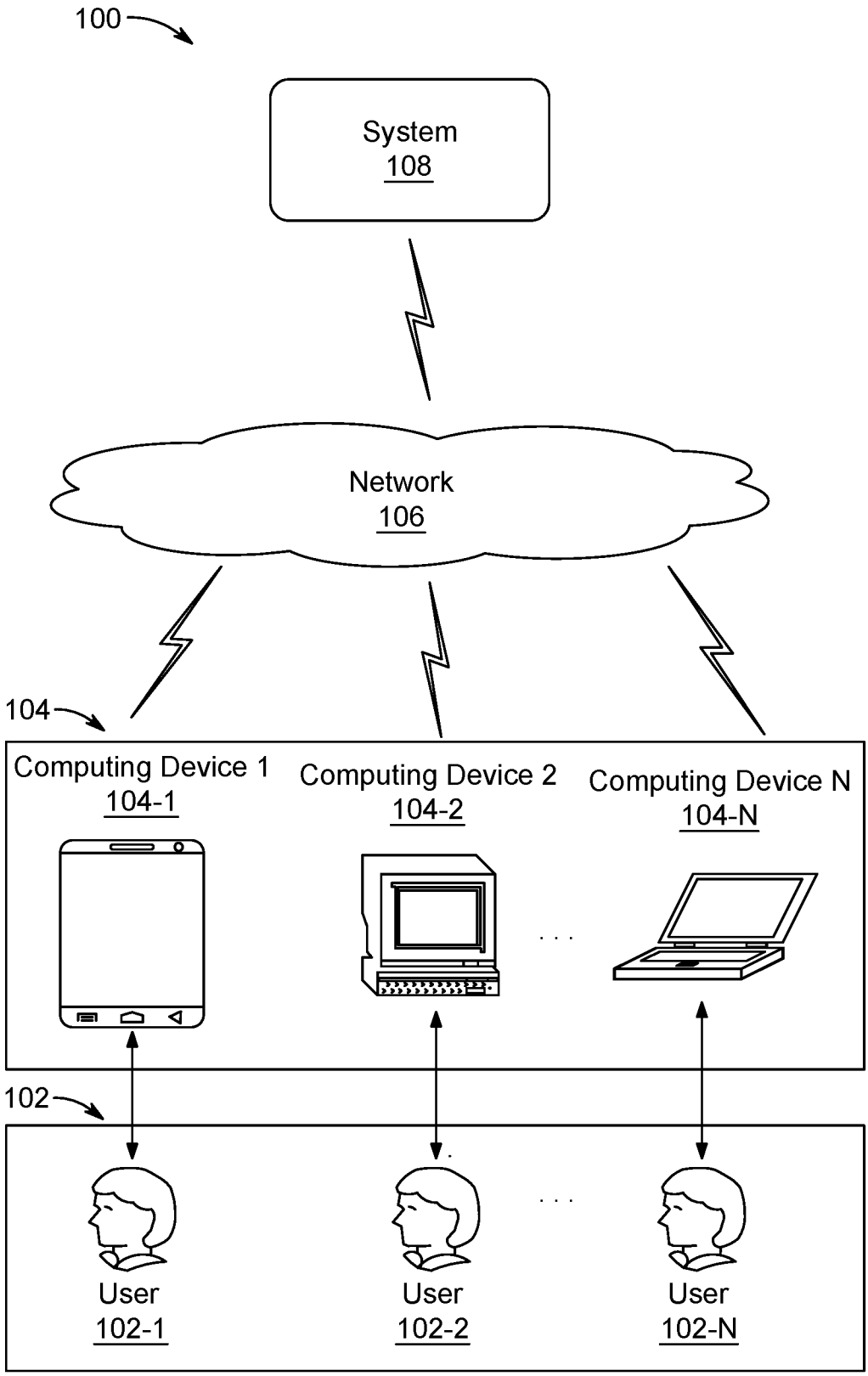
100
System
108
Network
106
104
Computing Device 1
104-1
Computing Device 2
104-2
Computing Device N
104-N
102
User
102-1
User
102-2
User
102-N

FIG. 1

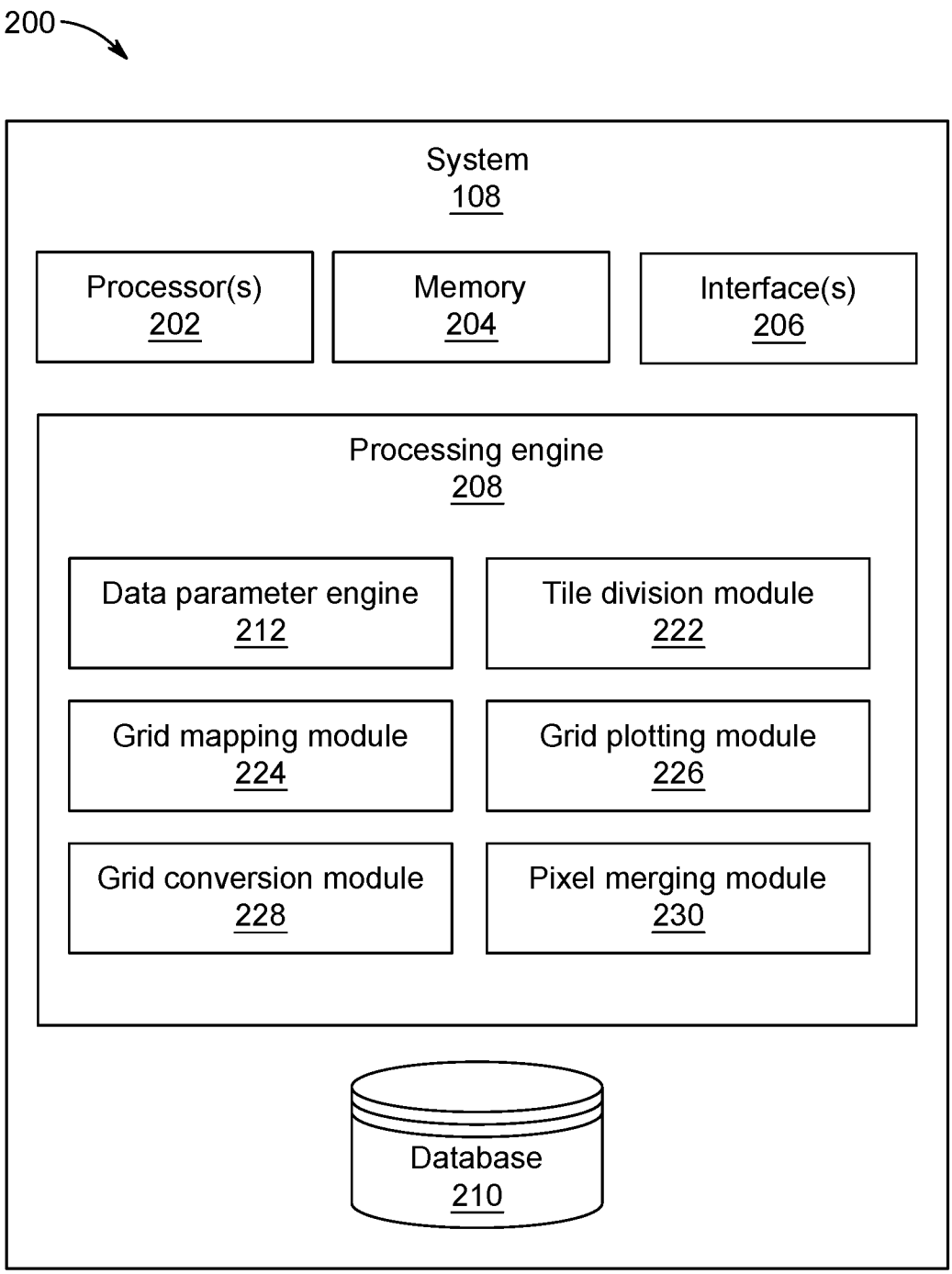
200
System
108
Processor(s)
202
Memory
204
Interface(s)
206
Processing engine
208
Data parameter engine
212
Tile division module
222
Grid mapping module
224
Grid plotting module
226
Grid conversion module
228
Pixel merging module
230
Database
210

FIG. 2

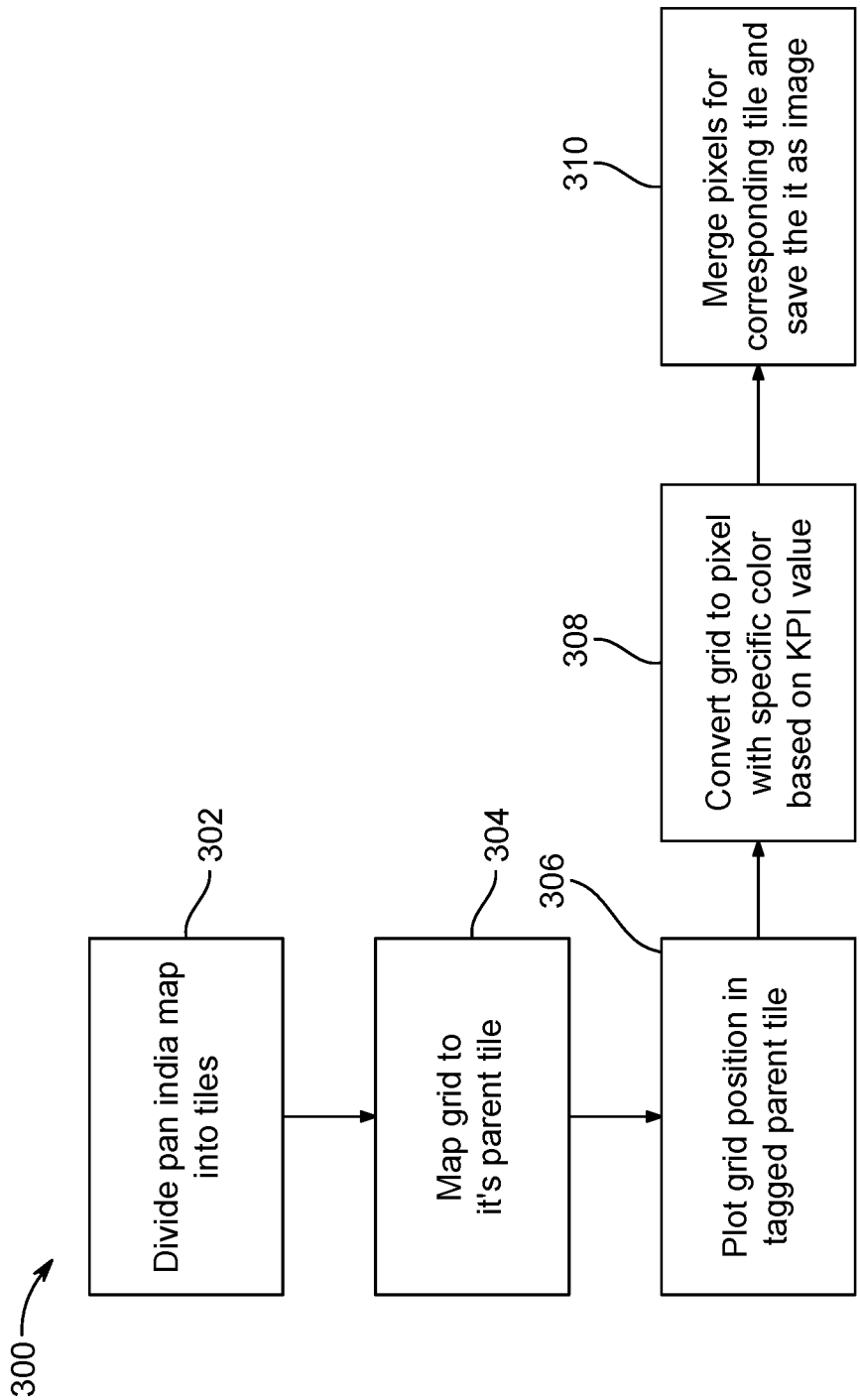
300
Divide pan india map into tiles
302
Map grid to it's parent tile
304
Plot grid position in tagged parent tile
306
Convert grid to pixel with specific color based on KPI value
308
Merge pixels for corresponding tile and save the it as image
310

FIG. 3

400A

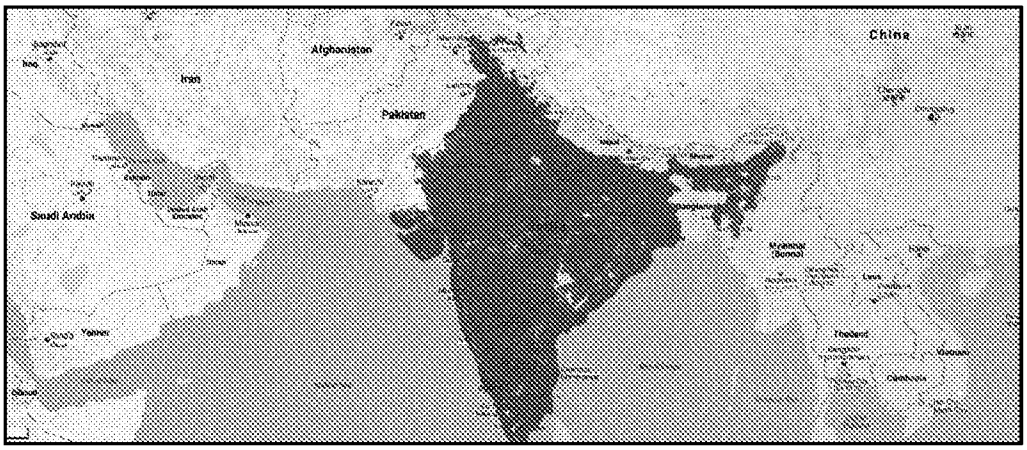

FIG. 4A

400B

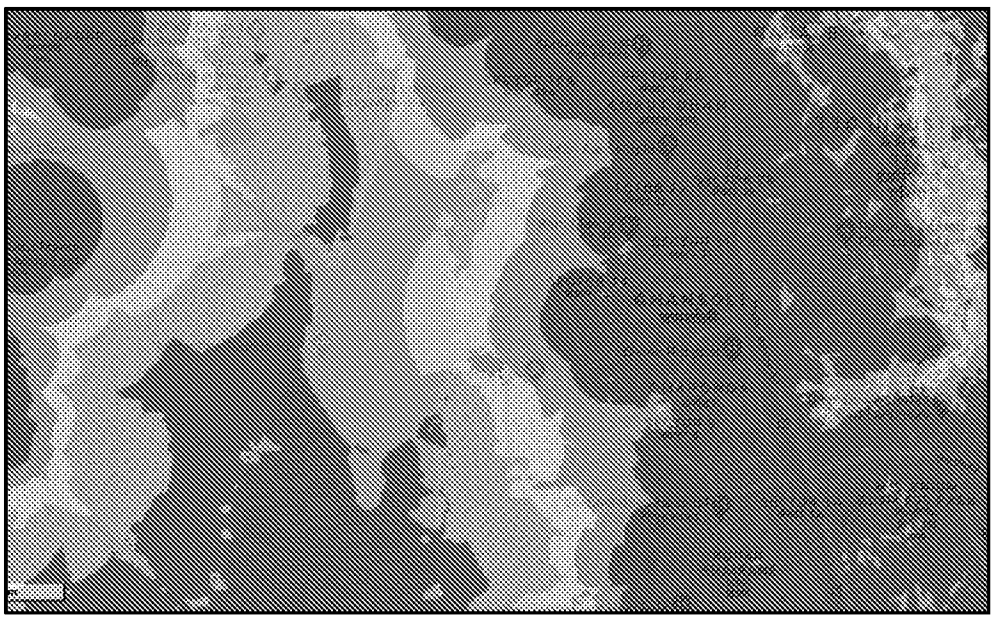

FIG. 4B

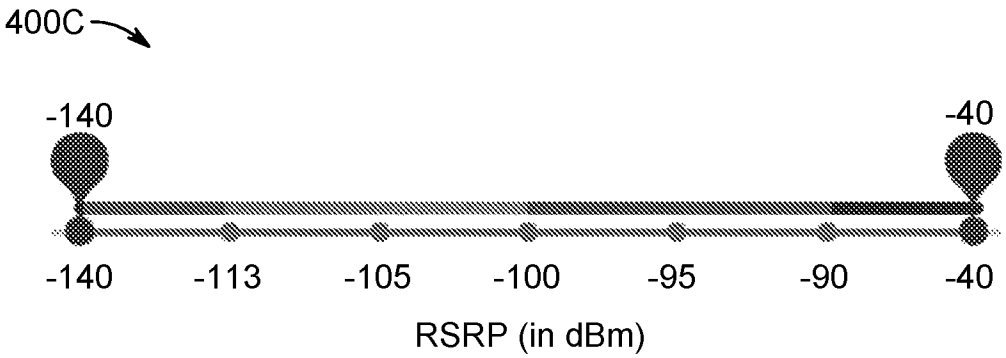

FIG. 4C

400D

Name	Number of Ranges
Custom	3
(Max.25 Characters) 7/25	(Min. 2 Max. 10)

#	Colour	Min.	Max.	Legend
1		-100	-40	-100<=RSP....
2		-120	-100	-120<=RSP....
3		-140	-120	-140<=RSP....

FIG. 4D

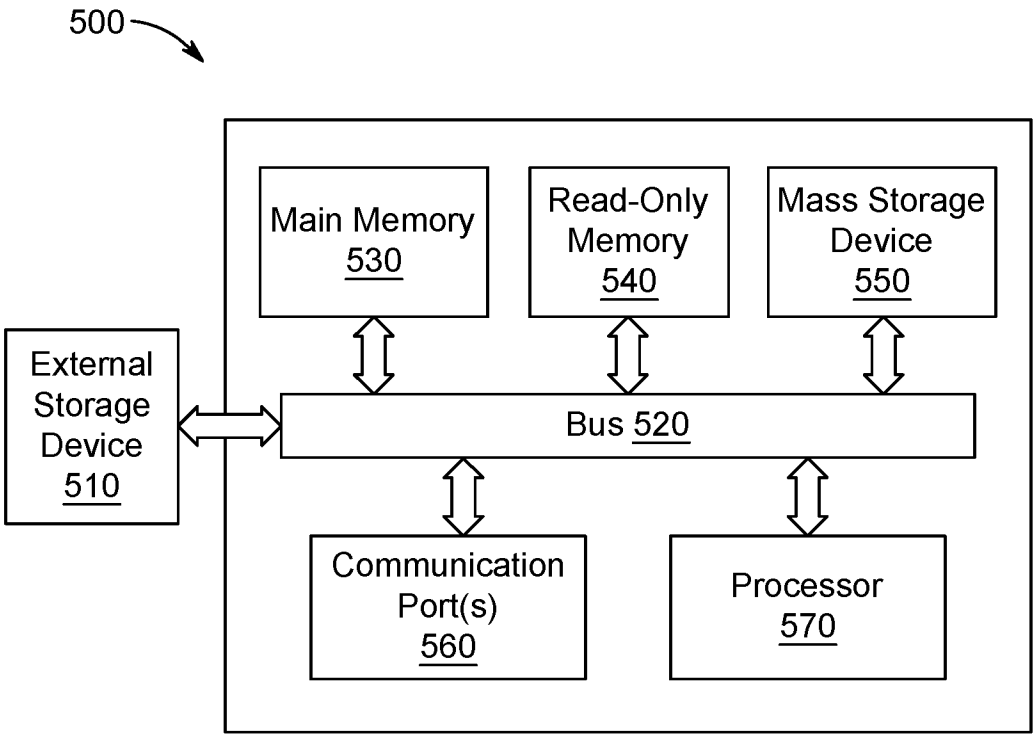
500
Main Memory
530
Read-Only
Memory
540
Mass Storage
Device
550
External
Storage
Device
510
Bus 520
Communication
Port(s)
560
Processor
570

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2024/050687

A. CLASSIFICATION OF SUBJECT MATTER
H04W24/08,H04W16/18,H04L43/045,H04L41/14 Version=2024.01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

PatSeer, IPO Internal Database, Google Patents
Keywords - divide, map, tile, grid, link, pixel, KPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US20050270299A1 (GOOGLE LLC) 08 DEC 2005 (08-12-2005) Para. [0032-0040], [0042-0049], [0050-0058], [0059-0064]	1-12

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13-09-2024	13-09-2024
Name and mailing address of the ISA/ Indian Patent Office Plot No.32, Sector 14,Dwarka,New Delhi-110075 Facsimile No.	Authorized officer Saurabh Saxena Telephone No. +91-1125300200

Citation	Pub.Date	Family	Pub.Date
US 20050270299 A1	08-12-2005	US 2010020091 A1	28-01-2010