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IDENTIFYING VEHICLE ROUTE BASED ON USER ACTIVITY

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ABSTRACT

Techniques are presented herein for an algorithmic framework to select the best vehicle route based on user activity. A minimum wireless service level is guaranteed in each leg of the route by accounting for anticipated user activity and localized network overloads estimated from route queries.

DETAILED DESCRIPTION

With the ever increasing need to stay always connected (e.g., to enable augmented reality features on a car dashboard, support teleconference, consume location specific content, etc.), reliable connectivity with service guarantees is necessary. Unfortunately, with the increased adoption of such wireless networks, severe spectrum scarcity is already being witnessed.

On the one hand, there is a great push to explore recently unlicensed spectrum (e.g., millimeter wave (mmWave), THz bands, etc.). On the other hand, solutions are being worked out to improve spectrum utilization. One such solution is TV White Spectrum (TVWS). For TVWS, standards bodies like the Federal Communications Commission (FCC) strongly recommend the querying of geo-location databases to obtain spectrum availability information.

The problem is to identify a commuter route in which wireless service level guarantees are met for user preferences/activities. A minimum wireless service level for each leg of the journey is set based upon the applications/activities the user is anticipated to be doing at various time points along the path. For example, based upon calendar entries for online collaboration meetings or favorite streaming shows/stadium events, the system may determine with high confidence from social media, etc.

Also, the system may estimate the additional load on cells by treating route queries as a sort of reservation. For example, if a section of vehicles are heading to a football game and have queried for routes with good coverage allowing them to watch the pre-game programs, this system may recognize that, and might route those not going to the game but interested in good network performance further away from the stadium. This system may reroute the path around localized network overloads or cell outages (keep-out areas) or fiber cuts.

The algorithm works by minimizing a wireless service level metric determined using a rich set of relevant system parameters to identify the best route.

The best vehicle route may be identified in the following manner**:**

A real-time road traffic Application Programming Interface (API) query is made to retain only the candidate routes P based on a commute time that is tolerable for a commute between S and E. Next, wireless network data API queries are made on each leg corresponding to routes in P. The candidate routes in P are re-ranked based on maximizing a cumulative wireless service level $W^{P}_{S\text{->}E}$ (refer to [1]). The re-ranked paths are trimmed, giving P'. P' is rendered on a street map for the user to make a pick further based on perceived convenience/familiarity.

The model for the cumulative wireless service level may be provided as follows:

$$W^{P}_{S\text{->}E} = \sum_{P} c_{i\to j} \times [w_{i\to j} - w_{i\to j,\min}] \times (\tau_{i\to j})^{-1} \text{ s.t. } w_{i\to j} > w_{i\to j,\min} \text{ for all } i, j. \quad [1]$$

where,

$w_{i\to j,\min}$: minimum wireless service level mandated in a leg $i\to j$ of the journey

$w_{i\to j}$: assured wireless service level in a leg $i\to j$ of the journey

$\tau_{i\to j}$: average commute duration in a leg $i\to j$ of the journey

$c_{i\to j}$: weight indicating user's perceived convenience, familiarity for a leg $i\to j$ of the journey

Model parameters for cumulative wireless service level in [1]

Estimating the assured wireless service level, $w_{i\text{->}j}$, in each leg of the journey, using a rich set of Wi-Fi®/LTE system parameters together with the localized network load (calculated using route queries as a proxy), and $w_{i\text{->}j,min}$, computed using the current and anticipated user activity/application. Parameters like minimum bandwidth, latency, jitter, outage duration, or drop probability are some relevant system parameters.

In the case of Wi-Fi® signals, the following parameters may be of interest: GeoTagId, longitude, and latitude; Service Set Identifier (SSID); security level; power level; and channel. In the case of LTE signals, the following parameters may be of interest:

latitude and longitude; type (e.g., 3G, 4G, Wideband Code Division Multiple Access (W-CDMA), etc.); Received Signal Strength Indication (RSSI) average and/or RSSI variance and SSNR; Channel Quality Indicator (CQI); downlink and uplink bandwidth; connection delay and delay (delay_of_ping); and packet delivery ratio.

Once the commute is in progress (e.g., current location S'), the same method may recalculate in real-time a route between S' and E and continue to iteratively rank the candidate routes.

Figure 1 below illustrates an example process.

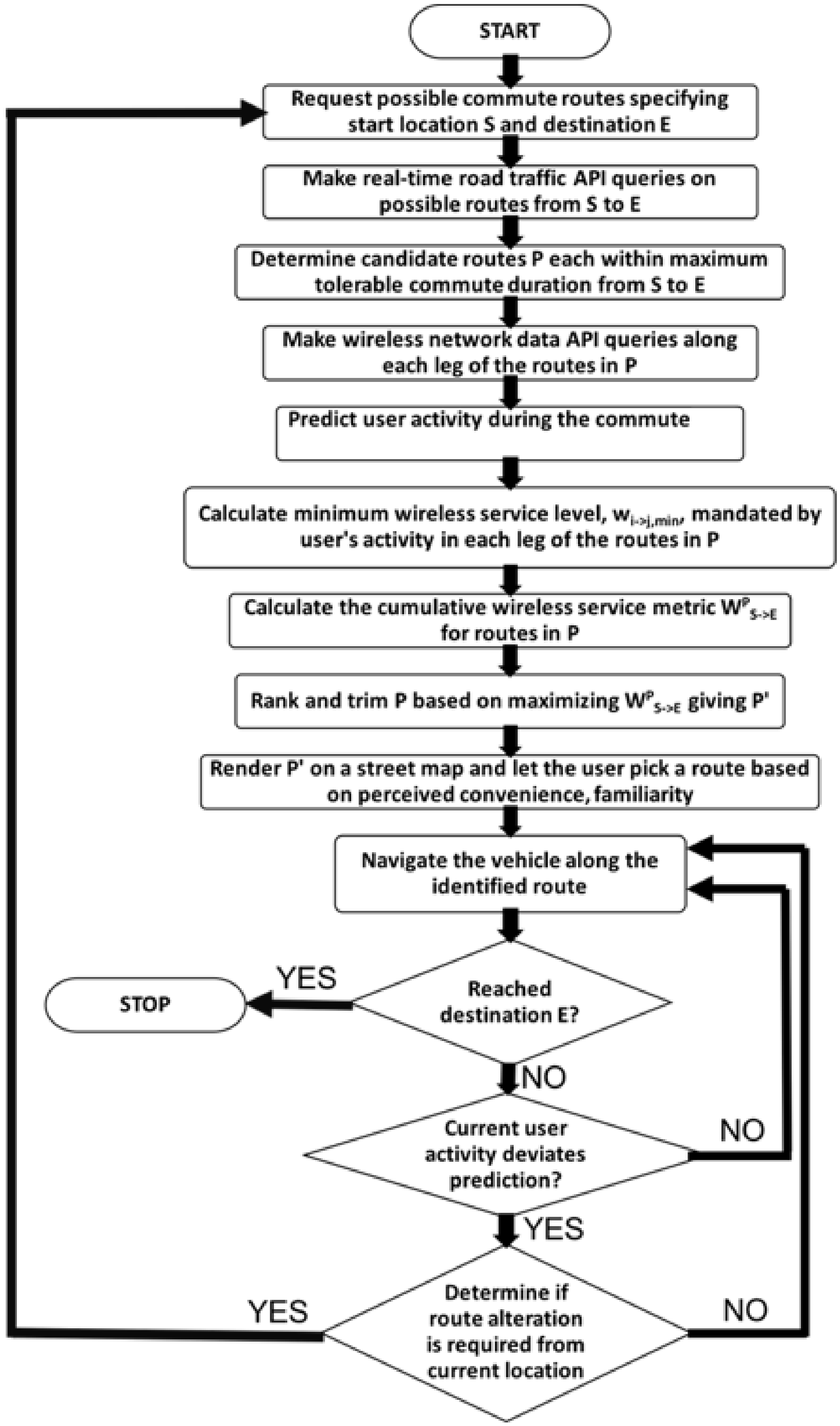

Figure 1

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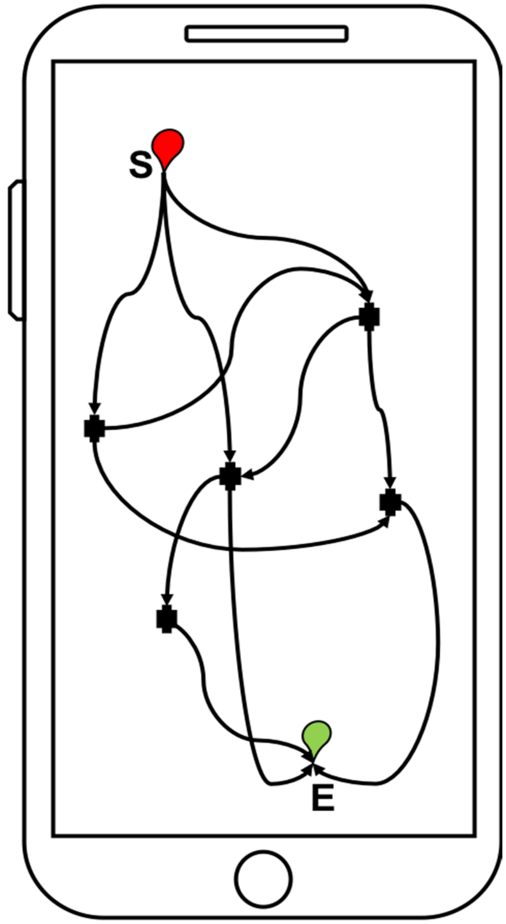
Figure 2 below illustrates example potential routes.



Routes in P'

Figure 2

Figure 3 below illustrates an example selection of one of the potential routes.

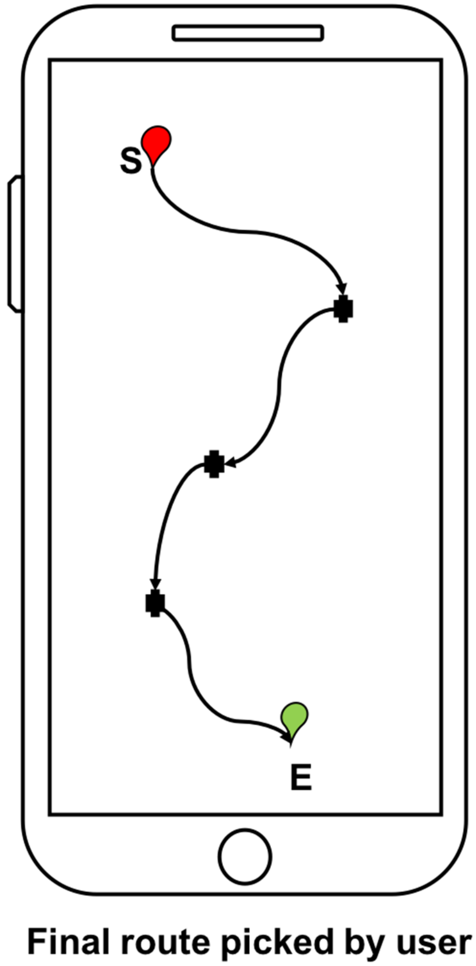


Figure 3

In summary, techniques are presented herein for an algorithmic framework to select the best vehicle route based on user activity. A minimum wireless service level is guaranteed in each leg of the route by accounting for anticipated user activity and localized network overloads estimated from route queries.