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Human Factors-aware Service Scheduling in Vehicular Cyber-Physical Systems

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Abstract- **It is essential to consider drivers' perceptions and reactions when building *Vehicular Cyber-Physical Systems* (*VCPS*) since the effectiveness and efficiency of VCPS will largely depend on how drivers could benefit from such a system. This paper considers, for the first time, novel service scheduling problems from *Human Factors* (*HF*) standpoint by taking into consideration the following fact: a driver may not be able to receive more than one service in a short period of time, even if the VCPS can somehow transmit multiple services to the driver from the conventional communications and networking standpoint. We study a family of the *HF-aware Service Scheduling* (*HFSS*) *Problems*, where the goal is to deliver up to *n* services, each having a time-dependent (and non-increasing) utility to a subset of intended drivers so as to minimize the system-wide total utility loss due to unsuccessful delivery of some services. We show that such problems are different from all existing problems. We formulate the basic HFSS problem (BHFSSP) using Integer Linear Programming (ILP) and prove it and other more general problems to be NP-Complete. We also propose efficient heuristics and present numerical results from large-scale test cases.**

Keywords-Service Scheduling; Human Factors; Vehicular Cyber-Physical Systems; ITS; VANET; NP-Complete

when *designing/building VCPS,* and such issues have not been adequately addressed. In particular, how to effectively deliver VCPS services, such as parking navigation, traffic signals, safety warning message etc., to a set of drivers, according to their perceptions and reactions still remains untapped. In this paper, we will take a fresh look at service delivery in VCPS from HF standpoint that departs from existing research on ITS/VANET which focuses only on communications and networking issues.

On the other hand, prior research on HF has revealed several facts that serve as guidelines for our work. For example, information processing in the human brain can be simulated by a queuing network composed of the Perceptual (performing visual/auditory processing), Cognitive (modeling the central executive), and Motor Subnetworks (sending information to body parts) [3]. Each subnetwork has a limited capacity and takes time to perform a task. Based on the queuing network model proposed in [3], when studying service delivery in VCPS, we assume that a successful service delivery process goes through the following three steps at each driver, each taking a certain amount of time: 1) a service provider (hereafter also called sender) sends a service message or content, 2) a driver (hereafter also called receiver) processes the service and makes a decision, 3) the driver responds to the service by taking the appropriate actions, e.g. maneuvering. In addition, since it is important for a driver to finish the three-step process with little delay or distraction,