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Secure Data Access Over Wide Area Network Using Vanet Protocol

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ABSTRACT
Vehicular Adhoc NETwork (VANET) is one of the most important and unique applications. On the contrary to traditional network architecture, VANET does not require a fixed network infrastructure; every single node works as both a transmitter and a receiver. Nodes communicate directly with each other when they are both within the same communication range with their neighbors using relay messages. The self-configuring ability of nodes in MANET made it popular among critical mission applications like vehicular network use or emergency recovery. Manual toll tax collection requires vehicles to stop and pay. This results in long delays that nullify the aim of rapid transit of the toll roads. Existing pay as you drive techniques require offline payment and privacy breaching authentication process. VANET based privacy preserving secure pay while on move toll tax payment scheme is presented. The payment process is based on blinded coin in which the coin is obtained from the bank offline. As member of the VANET, a vehicle is a priori authenticated and makes online payment during the period it passes through the toll plaza
Keywords
VANET
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I. INTRODUCTION

Roads indeveloped countrieshave become aninfrastruc- tureofverylargeproportions.TheUnitedStatesofAmerica (US) hasthelargest road networkintheworld, with more than7million kilometres. The EuropeanUnion (EU) road networkhasapproximately5.8millionkilometres,butmuch more densely distributedthanintheUS.China's roadnet- work israpidlyincreasing,alreadytotallingmore than3.5 million kilometresin2007.

Ananalysis ofthestatisticsintermsofroadlength,coun- tryareaandGrossDomestic Product(GDP)showsthat,ex- cludingverylargecountriesinarea(morethan650,000km2, approximatelythesizeof France),almost allcountriesinthe top25GDP listhavemorethan1kmofroadlengthperkm2 ofsurface area. The onlyexceptionisNorway, number25th in2011GDP list,withamuch smaller ratio between road length andsurface area ofjust 0.29km/km2.The topplace belongstoBelgium (5.03km/km2),followedbytheNether- lands (3.27 km/km2)and Japan(3.20 km/km2). Twenty ofthecountriesinthetop25listofcountriesbyGDP are also inthe top25listby length ofroads. The exceptionsareverysmallcountriesinarea (SouthKorea, Netherlands, Switzerlandand Belgium),plusIran and Norway.

Itisclearthattheeconomyandsocietydepend heavilyon efficientroad networks.Approximately44%ofgoodstrans- portedinthe EUgobyroad. Moreover,peopletravelmainly byroad, with privatecars accountingfor73%ofpassenger trafficintheEU [13]. Despite the importanceofroads for economic growth,funds tobuild and maintainthisinfras- tructurearetypicallyunder highpolitical pressure,asthey relymainly ontaxation overgassales. SomeUSstateshave evenconsideredintroducingaspecialtaxonfuelefficientve- hiclesinorder tocompensateforlostrevenue. Asaresult,a 2009reportoftheAmericanAssociationofthe StateHigh- wayand TransportationOfficialsconcludes thatabout50% ofthe roads intheUSareinbad condition[9].The EUhas recentlyharmonisedthe leveloftaxeswith minimumexcise dutiesacross Europe [14].

Toll roadsare a common methodofrevenue generation forbuilding and maintaininghighways.The advantagesare thatusers supportmostofthe costs, eventhoughcarssub- sidizethedegradationcaused by heavy transportvehicles. The maindisadvantagesarethatalternativeroads areusu- allyburdenedbyvehiclesthatavoidpayingtolls,withallt he associatedconsequencesintermsofaccidents,roaddegr ada- tionandincreasedcongestion.Intrans- europeanroadtrans- port,somecountriesthathave toll-freehighways are espe- ciallyburdenedbytraversingtrafficfromneighbouringc oun- tries.Otherfinancingmodelsincludepublic-privatepartner- ships (PPP)where shadow tollsmeasuretrafficand public fundscoverthecostof tolls.Thesemodelshaveshownprob- lemsintermsofrisksharing mechanismsbyplacing anun- equal burdenonthepublic side[7]. Furthermore,demand forpublictransportationisalsolimited bytheavailabilityof highways withnocosttotheuser. Pay-as-yougoschemesas analternativetocirculationtaxhavebeenproposedincou n- triessuch astheNetherlands,where users would befitted with aGPS trackerthatwould charge an amountper dis- tancedependingonthe roadcategoryandtimeofday. Pub- licopinion hasbeen stronglyagainstthisscheme, although similar schemes forcarinsurancehave beenwelcomed.

In this position paper we propose a novel and disrup- tivescheme for funding theroad network infrastructure, based on revenues from virtualbillboardadvertising,that wouldleveragetheemerging technologiesof augmentedreal- ity onwindshieldsand vehicle-to-infrastructure(V2I) wire- lesscommunicationsinthe5.9GHz band. Our conceptis tomake virtualoutdooradvertisingvery similar totheads presentinthe most popularwebsites such as Facebookor Google, exploring personalisedand contextualisedcontent whichgreatly increases theadded valueofavirtualbillboard when comparedtothephysical roadside infrastructure. In ourapproach,the windshieldisseenasapremiumwebsite, with apotentialshare ofInternettimethatreflectsthe av- eragethreehours ofdaily windshieldexposure ofAmerican drivers [8].

Internetadvertisinggeneratesenough revenueforkeeping free mostofthe online content,while paywalledwebsites usually struggleto generatesufficientrevenue. The virtual billboardscouldprovide asimilar revenue model sincethey exhibitthesame flexibilityand targetedadvertisingofmo- bile ads without theconstraints ofthescreen size, while typicallyreaching anadultaudience with areasonablepur- chasing power.

II. AUGMENTEDREALITYONTHEW IND- SHIELD

Augmentedrealityonthewindshieldexists evenprior to theinventionofelectronicdisplays. The rear-view mirror centrallyplacedonthewindshieldhasbeeninventedtoau g- mentthe forward-lookingperspectiveofdrivers with rear- viewimages, improvingsafety asaresultofimprovedper- ception.Somepeoplemightarguethatsuchapurely opticalsystem cannotbeconsideredasanaugmentedreality(AR) system,asit lackstheintegrationofcomputer-generatedel- ementswith thereal world environment.In fact,modern rear-view mirrors can alreadybefittedwith electronically- controlledauto-dimming features,which is technicallyan electronic basedmanipulationofareal-worldreflection.Fur- thermore, somesidemirrors alreadysuperimposevisualalerts whenavehicleisdetectedinthe driver’s blind-spot[1].

Aside fromthe mainly opticalrear-view mirrors,GPS- navigatorsare probablytheearliestexamples of systems thatusethewindshieldasanARdisplay. Theearliestunits used thewindshieldto mountaportableelectronicdisplay that obscuredthedriver’s vision. To solvethis problem, somesystems usearear-facingvideocamera ontheportable devicetomergenavigational imageswith thereal-timevideo stream[16].This isknown asvideo-see-throughAR.Inad- ditiontothe displays fornavigationalinformation,somein- strumentconsolesinclude anembeddedscreenthatdisplays theviewfromavehicle-mountedinfraredorthermalcamera, implementinganightvisiondriver assistancesystem, capa- bleinsomecasesof identifyingandhighlightingpedestrians. The idea isthatthese small screens can augmenttheper- ceptionofdrivers whenthevisibilitythroughthe windshield islow,inasimilar fashion torear-view mirrors.

In modern high-end vehicles, thewindshieldisactually used as a transparentcanvas over which thenavigational images are projected[16]. Opticalsee-throughAR inthe contextofdriving has themajor advantageofallowing the augmentedcontenttobesuperimposedoveraverylargea nd ideally placed screen, whichistheglass-

basedvirtualwind- shield. Laserholographic projectionisanemerging technol- ogybeingapplied inthiscontext.The companyLightBlue Optics(LBO) hasbeendeveloping laser-basedvirtualimage displayscapable ofdisplayinghighbrightnesssignageathigh resolutionandinfull-colour [17].LBO's laserprojectionen- gine explorestheprocess oftwo-dimensionaldiffractionto createpictogramsthatare always in-focus and can bepro- jected oncurvedsurfaces, suchasawindshield.Apreviewof thepictographythatcanbedisplayedonawindshieldusing LBO technologyisshown inFig. 1A. Anotherexample of an augmentedrealitysystemalsobased inlaser projection istheVirtualCable system,beingdeveloped byacompany called Making VirtualSolid, LLC (MVS) [3]. The ideais tohavenavigationinformationbeingdisplayedtothedriver inthe formofavirtual3Dcable thatappearstobehang- ingovertheroad, providingaguideline thatthe driver just hasto followto reach thedestination.Figure 1Bprovides a snapshotofthefunctioningofthis VirtualCable.
Opticalsee-through ARcanalsobeimplementedthrough transparentLiquid CrystalDisplays (LCD),embeddedin thewindshield.In [20]wehave implementedan overtak- ingassistant,knownasthe See-ThroughSystem (STS) [19], whichcombines suchARtechnologywith low-latencyvideo streamingtransmitted between two vehiclesusingDedicated Short-RangeCommunications (DSRC). The result is the transformationoflong and vision-obstructingvehicles into see-throughtubular objects, which greatly facilitates the overtakingmanoeuvre. Figure 1Cshows asnapshotofthe functioningofSTS implementedusing atransparentLCD. Avideoofatest-drivewith thissystem isavailableat[6].
Several manufacturershave presentedaugmentedreality glasses thatcan also be used tocreate thedriver's aug- mentedvision of theroad. These have some important advantagesthatresultsfrom thewearablenatureofsuch equipment: whileeye-point alignment calibration oreye- tracking systems are typically necessary with windshield- based ARtechnology,wearabledisplays overcome thisprob- lembytheirvery nature. Nonetheless,theirdrawbacksare theneed towear glasses whiledriving and thestilllimited resolutionachieved bythese verysmalldisplays.

III. INTERNET ADVERTISING

Since theearly days oftheInternet,there has been an exponentialgrowth ofbothquantityand diversityofavail- able content. This growthgained attractionfromadvertis- ers, thatsaw an immense opportunitytoattractnew cus- tomerstotheirbusinesses. Contrastingto thetraditional out-of-homebillboardsorradio and TVadvertising,the on-

lineadvertisingismore flexibleby offering contextualand targetedadvertising.Itsdynamicnatureattractedthead- vertiserstoswitch asubstantialpartoftheirinvestments from traditionaltoonline advertising. This transitionpri- marilyemerged inthebeginning ofthe90'swhen thefirst advertisingbannersweresold[10].Sincethen, theInternet advertisingmarketincreasedexponentiallyto$7.1billion in 2001and $31.7 billion in 2011in theU.S [21]. Some ex- amplesofInternetadvertising are thedisplay, social and search-engineresultsadvertising. Keyplayers onthismar- ketare Google, Yahoo, Microsoft and recentlyFacebook. Theimpactinterms ofrevenue ishuge,with96%ofGoogle's revenue in2011coming fromadvertisingservices [11].
Most ofthecompaniesthatprovide advertisingservices use thecost-per-mile, cost-per-click and cost-per-view as theirsrevenue models. Cost-per-milemodel chargesadver- tisersforevery timean advertisingisdisplayed,such asa webbanner.Instead,with thecost-per-viewmodel, thead- vertiseronlypayswhenauserseesavideothatcontainsthe advertising.Furthermore, cost-per-clickonlychargeswhena userclicksontheadvertising,asthismodelintendstodrive theusertoaspecificwebsite.Variablessuchasthe content

. ofawebsite, the contentofasearch performedinasearch engine, thehistoryofaspecificuser orits localization,are the basefor the selectionofaspecificadvertisement.Often, theadvertisingservices useacookiethattracksthehistory ofauser,whichwebsites he/shevisited andadsthat he/she saw or clicked before. In thecase thatusers are using an accountthatisassociatedwith aproviderofthesekind of services,the adswillbetargetedwithimprovedinformation suchastheir tastesorrecentpurchases.
Recently,withtheadvent oftheevolution ofsmartphones, theadvertisingmodel hassuffered someevolutions.Mobile advertising

surpassestheInternetadvertising in termsof contextualadvertising.The inherentmobilityincreases the localizationfactor toselect thebest advertisingtodisplay. Furthermore, thedifferentecosystemsthatexistinsmart- phones such asiOS, AndroidorWindows Phone,enhance theadvertiserswith more rich dataaboutthe user tastes intermsofwhichapplications,websites orplaces arebeing visitedthe most. However, thescreenrealestateisaserious issuewithin the mobileadvertising,wherethere isalimited sizeavailablefor theadvertisingbanner. Anotherseriousconcern, are theunbearable costs associatedwith theIn- ternettraffic inside thecellular network. Inthepast, FCCaddressedasimilar issue with theprohibitionoftheFAX spam thatproliferatedinthe1980’s[15],which implicated high costs tothe user. The recenttrendsshowthatsmart- phones have alreadysurpassedthe traditionalcomputersin terms ofunits sold. Therefore, itisexpectedthatthegrowth ofmobile advertisingwilllevelthe internetadvertisingand eventuallyovercome it.

Note thatdrivers arethemain targetaudience ofaradio advertising,especially dailycommuters.However, itcannot provide localized and targettedadvertisingthatispossible onthe Internet.This couldchange inthenear futurewith theintegrationofInternetradioinconnectedvehicles,ort he alreadyannouncedSpotifyservices embeddedinvehicles.

IV. MODELLINGHIGHWAYBILLBOARDS

Inordertoproposevirtualbillboards,itisnecessary toun- derstandhowthesearedistributedalonghighways.Weiden- tifiedallthe billboardspresentintheA3highway (Porto- Valenc¸a)onbothdirections,usingaGPS loggerand aweb- cam recordingofthe trip. The highwayoperatorperiodi- callyreportson thevolume oftraffic dataper segmentof thehighway. We obtainedthelinear regression model for thenumberofbillboards$b_i=-5.988+0.001043v_i$,where $v_i$isthevolume oftrafficforsegmenti,withacoefficientof thedeterminationof$R^2 =0.9705$.

For each section, weobtainedan histogramofbillboards along thelengthofthe segmentdivided into10bins, corre- spondingtoequal 10%fractions. Afterwards,weadded allthecorrespondingbinsandobtainedtheoveralldistrib ution ofbillboardspersegment.Thelatter presentedasymmetri- calpattern,sowecollapsed the5higher binsinto thelower ones,whichallowedustoincrease thedatasetand simplify themodeltoonlyhalfofthesegment.Finally,weranadis- tributionfittingalgorithmand obtainedtheparametersfor theclosestmodel,whichinthiscasewasanegativebinomial distributionwiththeparametersr=1.604andp=0.06374 . InFig.2wecompare thebillboarddatawith theobtained distributionmodel.

With thesetwomodels weare able to estimatethe bill board placementsinotherhighways and create simulation
ard placementsinotherhighways and create simulation

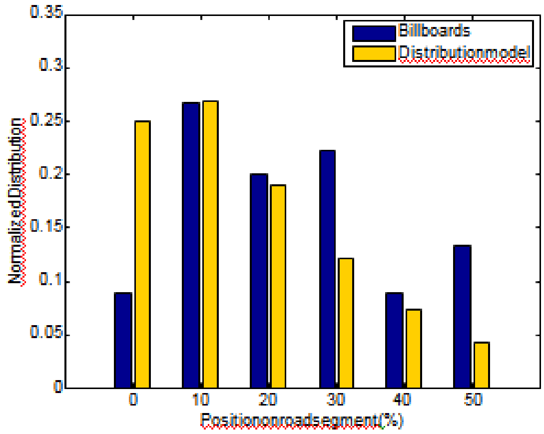

Figure2: Comparisonbetweenactualdistribution andobtainedmodel.

modelsforthe highway infrastructureinPortugal.Further- more, it provides an insightinto therationalebehind the placementofthese billboards,namely that theirnumberfor eachhighway segmentisproportionaltothevolume oftraf- fic.Moreover, billboardstend tobeplaced just after anen- tranceand justbefore an exit. This rationaleisconsistent withthebillboardscontentsincetheyareusuallyadvertising localproductsand servicesthatcanbefoundat subsequent exits ofthehighway.

V. BILLBOARDADVERTISING

Thephysical billboardsplaced onthe roadside ofanhigh- wayareexposedtothousandsofvisualizationsperday. Nev- ertheless,mostofthesebillboardsdisplay advertisingthat donotcapturedrivers attention,andmostlyduetothelack oftargeting.

The virtualbillboardaims toprovide an ad- vertisingthat isrelevanttothedrivers bydisplayingamore contextualand targetedadvertisingtailoredforeachdriver. Inthissection,wefirstdescribe thetechnicalcharacteristics ofoutdoorbillboardsand thenintroducetheconceptofa virtualbillboard.

5.1 Outdoor Billboard

Outdoorbillboardsare alsoknown inthe advertisingin- dustryasbulletins.Duetoitsnature,abulletinmustcom- plytocertainspecifications.According totheOutdoorAd- vertisingAssociationofAmerica (OAAA)[4], thesizeofa bulletinmustfitwithin11-21meters inwidthand3-6meters inheight. Often, theshape ofthe billboardismodified in order to visually enhance somespecificcharacteristiconthe displayedadvertising. Ads placed onthesebillboardsusu- ally stay inplace during longperiods, typicallymore than one month,and in Portugalsuch advertisingcosts about 700e/month.Digital billboardswere introducedto pro- videamoreflexiblewayto display advertisingonabulletin. Whiletheir formatresembles thetraditionalbillboard,their contentcanchange morefrequently,suchasweekly,dailyor evenhourly. Furthermore,displayed adsaremoredynamic, having thepossibilitytohaveembeddedvideoand multiple layouts,within thelimits imposed bylocalregulations.

To maximizetheprofitabilityofboth billboardand the displayedad,theplacementofbillboardstakesinto account its exposuretime, intermsofvisibilityand numberofdif- ferentviews. Usually, billboardsare placed atthe roadside ofahighway, near topopulous areas, orontopofbuildings. Still,theproliferationofbillboardshasbeen areal concern duetoitsvisual pollution.SomeU.S.statessuchasAlaska orHawaii donotallowoutdoorbillboards,and in2007the city ofSãoPaulo prohibitedalloutdooradvertising[2]. Intermsofmarketshare and exposure time, asshown in Fig.3,out-of-homeadvertisingrepresentsa27%ofthe con- sumerexposure time, eventhoughitonlygenerates4.4%of therevenue. The informationprovidedby[4]aggregatesall out-of-homeadvertisingand notjust billboards. However, thisfurtheremphasisesthedisparitybetween exposuretime and revenue.

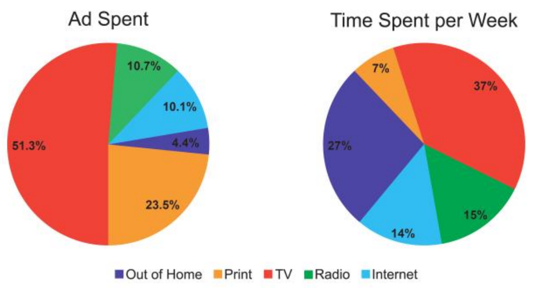

Figure3: Marketshareandtimespentperweekfor eachadvertisingmedium.

5.2 VirtualBillboard

Thearchitectureofthevirtualbillboardisbuilt uponV2I communicationbetween thevehicle and thebillboard,as presentedin theFig. 4. To keepbackwardcompatibility withexisting roadside billboardsarchitecture, the virtual billboardvirtuallysuperimposesexisting billboardswiththe virtualadvertising.Both vehicleand billboardmusthave a DSRC radio, and the billboardmust be connectedtothe Internet.Internetconnectioncan beavailableoneach bill- board orclusterscan beformed inorder to share asingle Internet connectionforcostreductionpurposes.Byhaving each billboardconnectedtothe advertisingnetwork,there isan unlimitednumberofadvertisementstodisplay. This advertisingnetworkwillretainallthe relevantinformation abouteachregistereddriver.

The selection ofanadvertisingissimilar tocurrentmeth- odsused on the Internet,using thedriver's own personal preferences,advertising history,driving history,etc. This implies thateach advertisingdisplayedwillhave different variablesto process, ultimatelyleading todifferentadver- tisingsdisplayedoneachvehiclethat iswithin thevisibility range ofaspecificphysical billboard. Inorder tocorrectly createthevirtualbillboard,anaccuratelocalizatio nofboth vehicle and physical billboardisneeded. The vehicle can beinthecommunicationrange ofthephysical billboardbut notinthevisibilityrange since thevisibilityrange can be affectednotonlybyterrainobstacleslike treesandhills,but alsobyenvironmentalissuessuchasdense fogand rain.

The communicationprotocol relies on theperiodic bea- coning enabled intheDSRC radios, defined asCooperative AwarenessMessage (CAM) [18]. Each vehicleperiodically advertises itsadvertisingnetwork's userIDanditslocation.

Uponreceivingeachbeacon, thephysical billboardevaluates

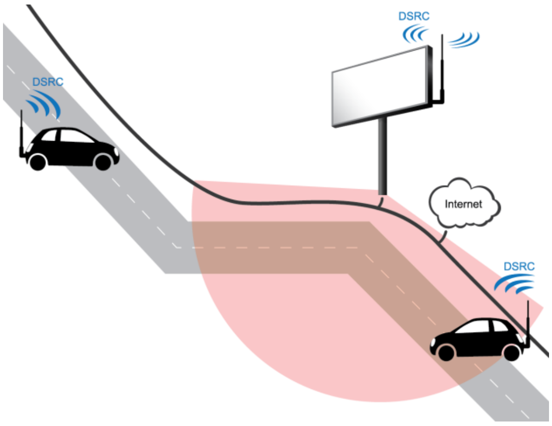

Figure4: ArchitectureoftheVirtualBillboard.

ifthevehicleisorwillbeinitsvisibilityrange. Inthatcase, theuserIDwillbeusedto automaticallyselectthebestad- vertisementto bedisplayedonthisparticularvehicle. After thisselection,the advertisementwillbesenttothe vehicle inorder tobedisplayedonitswindshield.Computervision in thevehicle visually detectstheposition ofthephysical billboardintermsofthe driver's point-of-view,and creates thevirtualbillboardby overlappingthe physical billboard with the targetedadvertising.

VI. PROOF-OF-CONCEPT

Takingtheconceptofa virtual windshielddiscussed in Section2,weenvisioned thetransparent LCDasthe perfect way toenable theaugmentedrealitywithin thevehicular environment. Based on thisconceptand in order tocre- ateaproof-of-concept,weperformedan experimentbased onvideorecording,computervisionand imageoverlapping. Asthe conceptonthispaper focusonhighways,thisexper- imentwasperformedonthesame highway asinSection 4. We filmed thedriver's perspectiveofthehighway with a camera,with a resolutionof1280x720 ata frame rateof 30fps. Thisvideoallowedustovirtuallyreproducethedriv- ingexperience withahighdegree ofrealism.

For thisproof-of-concept, we created digital advertise- mentsthatsuperimposeon theexisting roadside physical billboards. We assumethatthe physical billboardscan ei- theruse achromatickeytechniqueornear-infraredmark- ersthat areeasilydetectedbydigitalcamera sensors. This billboardwouldthen bedetectedusingcomputervision,as- sistedbyGPS informationand othercharacteristicstrans- mittedby thebillboardover DSRC. In eachvideo frame, wereplaced thephysical billboardwith apinkcolouredbill- board. We usedtheOpenCVlibrarytoprogrammatically detectit. Byusing thesegmentationtechniqueweareable todetectwherethephysical billboardisplacedandthenvir- tuallyreplace itbyadigital advertising.Asample snapshot ofthisrepresentationcanbeseenintheFig.5. Wecanobserve thedigital advertisingcorrectlysuperim- posedonthephysical billboard,beingseamlesstothedriver. The proof- ofconceptcanbeseeninvideoin[5].

VII. BILLBOARDSPONSOREDHIGHWAYS

In ordertoanalysethe viabilityofbillboardsponsored highways,wefirstobtainthe toll-basedrevenue followedby ananalysis ofthe advertising-basedrevenue necessary to re- placethese tolls.The equivalentcostperbillboardforeach highway segmentwas obtainedby splittingthe toll-based revenue bythe numberofbillboards.This numberwasesti- matedbyapplyingthemodelobtainedinSection4tot heA1 highway (Porto-Lisboa),which has 19segmentsand about 300km. In Fig. 6, wepresentthedaily costper billboard fortheactualtollvaluesandcompareitwiththefixedprice of0.08e/km,which isdefined by law asthereference toll price/kminPortugal.Thevaluesareordered fromlowestto highest inorder toobserve thenumberofhighway segments thatcould become fully sponsoredfor different threshold values.

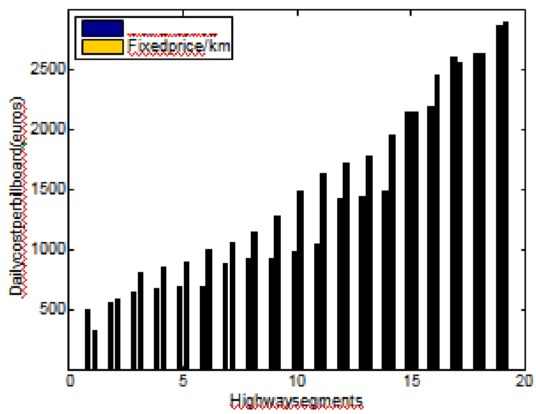

Figure6: Equivalentcostperbillboardfortollbased revenue.

Sincethesebillboards wouldprovide targetedadvertising, thedaily costper billboardshould be analysedin terms ofthenumberofviewsper day. Therefore,weobtainthe billboardadvertising costper vehicle based on thenum- ber ofvehicles foreach highway segment.Furthermore,we analysedifferentscenarios intermsofthe impactofswitch- ingfromtoll-basedrevenue to billboardsponsored revenue. First, itisreasonabletoassume thatremoving tollswould increase thevolume oftraffic, since theinverse happened when Portuguesehighways with shadow tollsswitchedto real tolls[12],with reductionsup to 50%inthevolume of traffic. Second, the billboardsponsoredhighway segments can either maintainthesame revenue and absorb thein- creased trafficorreflectthisincrease inthe billboardspon- sorship, therebygeneratinganhigher revenue. InFig.7,we presentthesedifferentmetrics forobtainingtheadvertise- mentcostper vehicle. Weused thesame order ofhighway segmentsasinFig.6inorder toprovide bettercomparison.

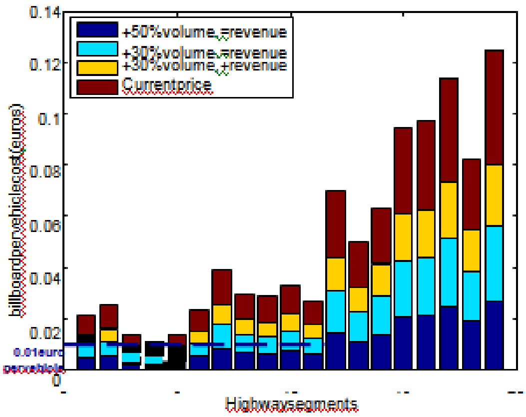

Figure7: Advertisingcostpervehicleforbillboard sponsoredhighways.

These results show that11outof19highway segments could become fully sponsored and therefore free to users with advertisingcostsaslowas0.01e/vehicle.InFig.7,we observethat11segments staybelowthethresholdwhencon- sideringa50%increase intraffic due to providingtoll-free highways. Even whenconsideringa30%increase intraffic and charging advertisersforthisextra traffic, the threshold wouldbearound0.02e/vehicle.

VIII. CONCLUSIONS

In thisposition paper wepresentvirtualbillboardsthat combine theflexibility ofInternetadvertising,thecontex- tualawarenessofmobile advertisingand the highexposure ofroadside billboards. We presentan architecturebased on DSRC V2I communications and enhancedreality dis- plays thatallowsfordigitalads tobesuperimposedonex- istingphysical billboards. We demonstratethe conceptof virtualbillboards using currenttechnologiesand presenta video illustratingthe system. Finally,wepresentthe fea- sibilityanalysis ofbillboardsponsoredhighways and show thatmany highways with high volume oftraffic could be supportedfromthe advertisingrevenue alone.

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