Using AMOV ESoV Algorithms And Sharing In The Clouds

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Abstract—**Demands on videotraffic over mobile networks have been souring,thewirelesslinkcapacitycannot keep upwith thetraffic demand.Thegapbetweenthetraffic demandandthe linkcapacity,alongwithtime-varying link conditions, resultsin poor service qualityofvideostreamingovermobilenetworkssuch aslongbufferingtimeandintermittentdisruptions. Leveraging thecloudcomputingtechnology, weproposeanewmobilevideo streamingframework,dubbedAMES-Cloud,whichhastwomain parts:adaptivemobilevideostreaming(AMoV)andefficientso-cialvideosharing (ESoV). AMoV andESoVconstruct aprivate agenttoprovidevideostreaming servicesefficientlyforeachmo-bileuser.Foragivenuser,AMoVletsherprivateagentadaptively adjustherstreamingflowwithascalablevideocodingtechnique basedonthefeedbackoflinkquality.Likewise,ESoVmonitorsthe socialnetworkinteractionsamongmobileusers,andtheirprivate agentstrytoprefetchvideocontentinadvance.Weimplement a prototypeofthe AMES-Cloudframeworktodemonstrateitsper-formance.Itisshownthattheprivateagentsinthecloudscaneffec- tivelyprovide theadaptivestreaming,andperform videosharing (i.e., prefetching)basedon thesocialnetworkanalysis.**

Index Terms—**Adaptivevideo streaming,cloudcomputing,mo-bilenetworks,scalablevideocoding,socialvideosharing.**

I.INTRODUCTION

The past decade, increasingly more traffic is accounted by video streaming and downloading. In particular,videostreamingservicesovermobilenetworkshavebecomeprevalentoverthe pastfew years[1].Whilethevideo-streamingis notsochallenginginwirednetworks,mobilenet-workshavebeensufferingfromvideotraffic transmissionsover scarcebandwidthof wirelesslinks.Despitenetworkoperators' desperateeffortstoenhancethewirelesslinkbandwidth (e.g.,3GandLTE),soaringvideotrafficdemandsfrommobileusersarerapidlyoverwhelming thewirelesslinkcapacity.While receiving video streaming trafficvia3G/4G mobile networks, mobileusersoftensufferfromlongbuffering time andintermittent disruptions duetothelimitedbandwidth and link condition fluctuation caused by multi-path fading and usermobility[2]–[4].Thus,it is crucialtoimprovetheservice qualityofmobilevideostreamingwhileusingthenetworking andcomputingresourcesefficiently[5]–[8].Recently there have been many studies on how to improve the service quality of mobilevideos treamingontwoaspects:

- **Scalability:**Mobilevideostreamingservice shouldsup-portawide spectrum ofmobile devices; theyhavedif- ferent video resolutions,differentcomputingpowers,dif-ferentwirelesslinks(like3GandLTE)andsoon.Also, theavailable linkcapacity ofamobile devicemayvary overtimeandspacedependingon its signalstrength,other userstrafficin thesamecell,andlinkconditionvariation. Storingmultipleversions(withdifferentbitrates)of the samevideocontentmayincurhighoverheadin termsof storageandcommunication.

Adaptability: Traditional video streaming techniquesdesignedby consideringrelativelystabletraffic links between servers andusers,performpoorlyinmobile environments[2].Thusthefluctuatingwirelesslinkstatus should beproperlydealt withtoprovide'tolerable"video streamingservices.

Cloudcomputing techniques arepoisedtoflexiblyprovide scalableresourcestocontent/service providers,andprocessof-floadingto mobileusers[13]–[19].Thus,clouddatacenterscan easilyprovisionforlarge-scale real-timevideoservicesasin-vestigated in[9],[20].Severalstudiesonmobilecloudcom-putingtechnologieshaveproposedto generatepersonalizedin-telligentagentsforservicingmobileusers,e.g.,Cloudlet[21] andStratus[22].Thisis because,in thecloud,multipleagent instances(orthreads)canbemaintaineddynamically andeffi-cientlydependingonthetime-varyinguserdemands.

Recentlysocialnetworkservices(SNSs)have beenincreas-inglypopular.Therehavebeenproposalsto improvethequality of content delivery using SNSs [23], [24]. In SNSs, users mayshare,commentor re-postvideosamongfriendsand membersinthesamegroup,whichimpliesausermaywatch avideothatherfriendshaverecommended (e.g.,[24]).Users inSNSscanalsofollow famous andpopular usersbasedon their interests (e.g., an official facebook or twitter account that shares the newest pop music videos), which is likely to be watched by its followers.Inthispaper,wedesignaadaptivevideostreamingandprefetching framework formobile userswiththeaboveobjec-tivesinmind,dubbedAMES-Cloud.AMES-Cloudconstructsa privateagentforeachmobileuserincloudcomputingenviron-ments,whichisusedbyitstwomainparts:(i)**AMoV**(adaptive mobilevideo streaming),and **ESoV** (efficientsocial video sharing).

Therestofthepaperisorganizedasfollows.Wefirst intro-ducerelatedworkin SectionII, andexplaintheAMES-Cloud framework inSection III.Theadaptive video streaming serviceandtheefficientsocialvideosharing willbedetailed in SectionsIVandV, respectively.Thenthe operationsof AMES-Cloudis illustratedin SectionVI.Finally,weevaluatetheprototypeimplementation inSectionVII,andconcludethepaper inSectionVIII.

II. RELATEDWORK

A. AdaptiveVideoStreamingTechniques

Intheadaptive streaming, thevideotrafficrateisadjusted onthefly sothatausercanexperiencethemaximumpossible videoqualitybasedon hisor herlink'stime-varyingbandwidth capacity[2].Therearemainlytwotypesof adaptivestreaming techniques, depending onwhethertheadaptivity iscontrolled bytheclientor theserver.TheMicrosoft'sSmoothStreaming [27]isaliveadaptivestreamingservicewhichcanswitchamong differentbitratesegmentsencodedwithconfigurablebitratesand videoresolutionsatservers,whileclientsdynamically request videos basedonlocalmonitoring oflinkquality. Adobe and Applealsodevelopedclient-sideHTTPadaptivelive streaming solutionsoperatingin thesimilarmanner.Therearealsosome similaradaptivestreamingserviceswhere serverscontrolsthe adaptivetransmissionof videosegments,forexample,the QuavliveAdaptiveStreaming.However,mostofthesesolutions maintainmultiplecopiesofthevideocontentwithdifferent bitrates,whichbringshugeburdenofstorageontheserver.Regarding rate adaptation controlling techniques, TCP-friendlyratecontrolmethods forstreamingservices overmobilenetworks areproposed [28],[29],whereTCPthroughput ofaflowispredictedasafunctionofpacketlossrate,roundtrip time,andpacketsize.Considering theestimatedthroughput, thebitrateofthestreamingtraffic canbeadjusted.Arate adaptationalgorithmforconversational3Gvideostreaming isintroduced by[30].Then,afewcross-layer adaptation techniques arediscussed [31], [32],which canacquire more accurateinformation oflinkqualitysothattherateadaptation canbemoreaccurately made.However, theservershaveto alwayscontroland thus sufferfrom largeworkload. RecentlytheH.264ScalableVideoCoding(SVC)techniquehasgainedamomentum [10].Anadaptivevideostreaming systembasedonSVCisdeployed in[9],whichstudies the real-timeSVCdecodingandencodingatPCservers.

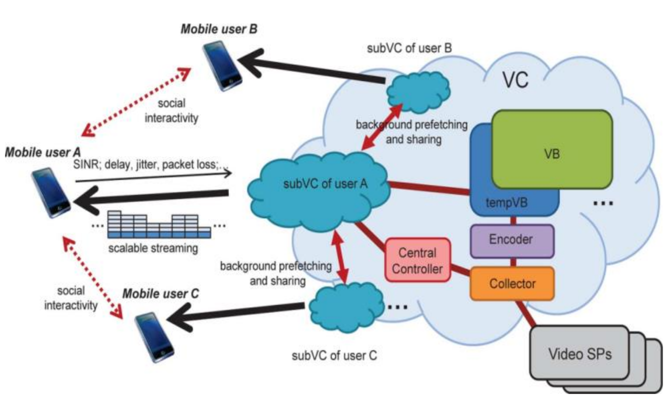

Fig.1. IllustrationoftheAMES-CloudframeworkwiththeVideoCloud(VC),subVCsformobileusers,theVideoBase(VB),andtheVideoServiceProviders(SPs).

III. AMES-CLOUDFRAMEWORK

InthissectionweexplaintheAMES-Cloud frameworkincludestheAdaptive MobileVideostreaming (AMoV) andthe EfficientSocialVideosharing(ESoV).AsshowninFig.1,thewhole videostoringandstreamingsystemin the cloudiscalledtheVideoCloud(VC).In the VC, thereisalarge-scalevideobase(VB),whichstoresthemostof thepopularvideoclipsforthevideoserviceproviders(VSPs).A temporalvideobase(tempVB)isusedtocachenewcandidates forthepopular videos, whiletempVB counts theaccessfrequencyofeachvideo.TheVCkeepsrunningacollectortoseek videoswhicharealreadypopularinVSPs,andwillre-encodethecollected videosintoSVCformatandstoreintotempVB first.Bythis2-tierstorage,theAMES-Cloud cankeepserving mostofpopularvideoseternally.Notethatmanagement work willbehandledbythecontrollerintheVC.Specializedforeachmobileuser,asub-videocloud(subVC) iscreateddynamically ifthereisanyvideostreamingdemand fromtheuser

B. MobileCloudComputingTechniques

Thecloud computing hasbeen wellpositioned toprovide video streaming services, especially in the wired Internet because of its scalability and capability [13]. For example, thequality-assured bandwidthauto-scaling forVoDstreaming basedonthe cloudcomputingisproposed[14],and the CALMS framework[33]isacloud-assistedlivemediastreamingservice forglobally distributed users. However, extending thecloud computing-based services to mobile environments requires morefactorsto consider:wirelesslinkdynamics,usermobility .

IV. AMOV:ADAPTIVEMOBILEVIDEOSTREAMING

AsshowninFig.2,traditionalvideostreamswithfixedbit ratescannotadapttothefluctuationofthelinkquality.Foraparticularbitrate,ifthesustainablelinkbandwidthvariesmuch,the videostreamingcanbefrequentlyterminateddueto thepacket loss.

InSVC,acombination ofthethreelowestscalabilityis calledtheBaseLayer(BL)whiletheenhanced combinations arecalledEnhancementLayers(ELs).Tothisregard,ifBL is guaranteedto bedelivered,whilemoreELscanbealso obtained whenthelinkcanafford,abettervideoquality can be expected.

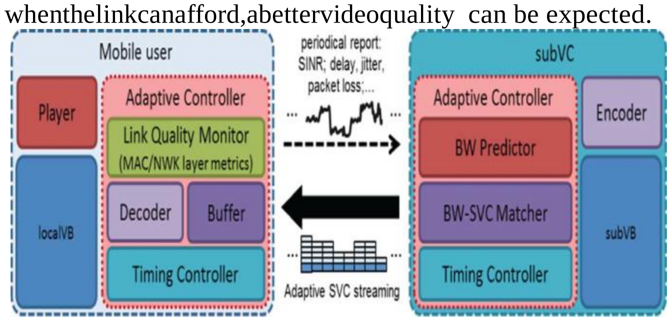

Fig2.traditionalvideostreamswithfixedbit rates

V. ESOV:EFFICIENTSOCIALVIDEOSHARING

A. SocialContentSharing

InSNSs,userssubscribe toknownfriends,famouspeople, andparticularinterestedcontentpublishers aswell;alsothere arevarioustypesofsocialactivitiesamongusersinSNSs,such asdirectmessageandpublicposting.Forspreading videosin SNSs,onecanpostavideointhe public,andhis/hersubscribers canquicklyseeit;onecanalsodirectlyrecommenda videoto specifiedfriend(s);furthermoreonecanperiodicallyget noticed bysubscribedcontentpublisherforneworpopularvideos.

Weclassifythesocialactivitiesin currentpopularSNSsinto threekinds,regardingtheimpactoftheactivitiesandthepoten- tialreactingpriorityfromthepointof viewof therecipient:

- **Subscription:**LikethepopularRSSservices,anusercansubscribe toaparticular videopublisher oraspecial videocollection servicebasedonhis/herinterests. This interest-driven connectivitybetweenthesubscriber and thevideopublisherisconsideredas“median”,becausethe subscribermaynotalwayswatchall subscribedvideos.
- **Directrecommendation:**InSNSs,anuserdirectlyrecom- mendavideotoparticularfriend(s)withashort message. Therecipientsof themessagemaywatchit withveryhigh probability.This isconsideredas“strong”.
- **Publicsharing:**EachuserinSNSshasatimeline- basedofactivity stream, which shows his/her recentactivities. Theactivity ofauserwatching orsharingavideocanbe seenbyhis/herfriends(orfollowers). Weconsider this publicsharingwiththe “weak”connectivityamongusers, becausenot manypeoplemaywatchthe videothat onehas seenwithoutdirect recommendation.

TABLE I SOCIAL ACTIVITIES AND BACKGROUND PUSHING STRATEGIES

	Direct recommendation	Subscription	Public sharing
VB→subVB	All	Parts	Little
subVB→locVB (via Wi-Fi)	All	Parts	Little
subVB→locVB (via 3G/4G)	Parts	Little	None

B. PrefetchingLevels

Different strengths ofthesocialactivities indicatedifferent levelsofprobabilitythatavideowillbe soonwatchedbythere- cipient.Correspondinglywe alsodefine threeprefetchinglevels regardingthesocialactivitiesofmobileusers:

- **“Parts”:**Becausethevideosthatpublishedby**subscriptions**maybewatchedbythesubscribers withanothigh probability,weproposetoonlypusha partofBLandELs segments,forexample,thefirst10%segments.
- **“All”:**Thevideosharedbythe**directrecommendations** willbewatchedwitha highprobability,so weproposeto prefetchtheBLandallELs,in orderto lettherecipient(s) directlywatchthevideowitha goodquality,withoutany buffering.

VII. IMPLEMENTATIONANDEVALUATION

Weevaluatethe performanceoftheAMES-Cloudframework byaprototypeimplementation.WechoosetheU-cloudserver (premium)inthecloudcomputing serviceofferedbyKorean Telecom,andutilizethevirtualserverwith6virtualCPUcores (2.66GHz)and32GBmemory, whichisfastenoughforen- coding480P(480by720)videowithH.264SVCformatin30fpsatre altime[9].Inthecloud,wedeployourserverappli- cationbasedon Java,includingone mainprogramhandlingall tasksofthewholeVC,whiletheprogramdynamically initial- izes,maintains andterminates instances ofanothersmallJava applicationasprivateagentsforallactiveusers.Weimplement themobileclientatamobilephone, Samsung GalaxyII,with androidsystem version 4.0.Themobile dataservice isoffered byLG LTEnetwork,whileinsomeuncoveredareathe3G networkisused.Notethatwestilluse“3G”toindicatethegen- eralcellularnetwork.Wetestinthedowntownarea,sotheprac- ticalbandwidthofthemobilelinkisnotashighasweexpected, butthiswon’timpactour experimentresults.

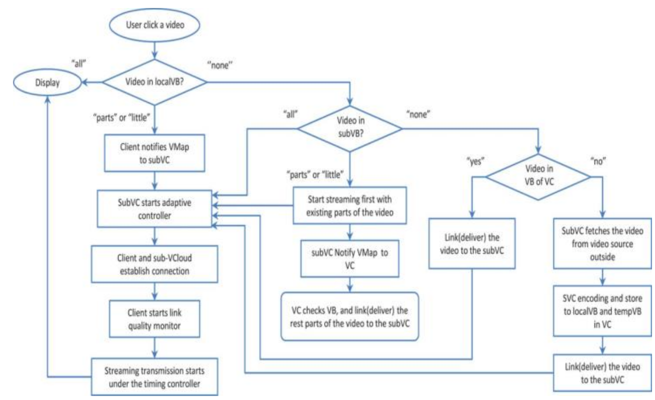

Fig. 3. WorkingflowofvideostreaminginthesubVC andVCofAMES-Cloudframework.

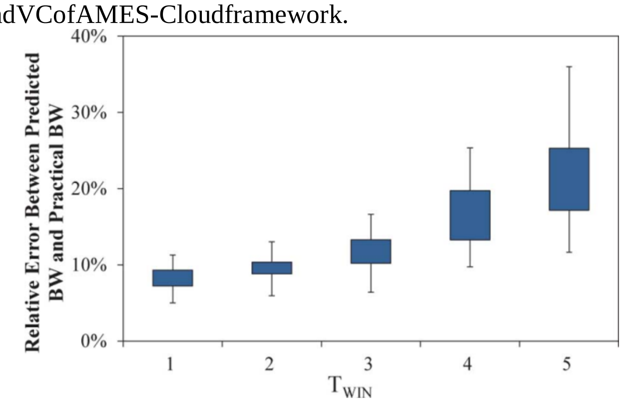

Fig.4. Relativeerrorsbetweenpredictedbandwidthandpractical bandwidth.

Firstlywe examinewhetherthereis a deeprelationship betweenthemeasuredbandwidthoflasttimewindowand the practicalbandwidthof next time window(goodputby Kbps).Wetestthevideostreamingserviceviacellularlink, andmovethedevicearoundinthebuildingtotrytochange thesignalquality.

WeevaluatehowH.264SVCworksinAMES-Cloudframe- workregardingtheabovementionedSVCresolutionconfigu- rations. AsshowninFig.7(a), because ofthestrongcomputa- tionalcapacitybythecloudcomputing,theencodingspeedis fast.Thebestresolution configuration“ ”with5secondtemporalsegmentationschemerequiresabout560ms for encoding.For shorterintervalsof T ,the encodingdelay isverysmallunder50ms.

VIII. CONCLUSION

Inthispaper,wediscussedourproposalofanadaptivemobile videostreamingandsharingframework, calledAMES-Cloud, whichefficientlystoresvideosintheclouds (VC), andutilizes cloudcomputing toconstruct privateagent(subVC)foreach mobileusertotrytooffer“non-terminating” videostreaming adaptingtothefluctuationoflinkqualitybasedontheScalable VideoCodingtechnique.AlsoAMES-Cloudcan furtherseekto provide“non-buffering”experienceofvideostreamingbyback- groundpushingfunctionsamongtheVB,subVBsandlocalVB ofmobileusers.WeevaluatedtheAMES-Cloud byprototype implementationandshowsthatthecloud computingtechnique brings significantimprovementontheadaptivityofthemobile streaming. wewillcarry outlarge-scale implementation and withseriousconsideration onenergyandpricecost.Inthefu- ture,wewillalsotrytoimprovethe SNS-basedprefetching,and securityissuesintheAMES-Cloud.

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