

Quality of experience metrics for cloud services: A systematic mapping

Ximena Guerrón^{1,2}, Sílvia Abrahão², Emilio Insfran², Marta Fernández-Diego², Fernando González-Ladrón-de-Guevara²

¹Universidad Central del Ecuador,
Quito, Ecuador
xguerron@uce.edu.ec

²Universitat Politècnica de València
Valencia, España
xiguesan@doctor.upv.es
{sabrahao, einsfran}@dsic.upv.es,
{marferdi, fgonzal}@omp.upv.es

APPENDIX 1. CLASSIFICATION OF QOE METRICS FOUND IN THE SYSTEMATIC MAPPING

Legend	
Data Extraction criteria	Possible Answer of each data extraction criteria
QoE characteristic	EF FE=Effectiveness, EF FI=Efficiency, SATI=Satisfaction, FREE=Freedom from risk, COCO=Context coverage
Metric	Name of the metric
Lifecycle phase	Req. = Requirements, Acq. =Acquisition, Dev. = Development, Int = Integration, Ope. = Operation, Ret = Retirement
Artifact evaluated	Spe. = Specification of cloud service, Arc. = Architecture of cloud service, Ser. = Cloud Service
Type of service	SaaS= Software as a service, PaaS = Platform as a service, IaaS= Infrastructure as a service
Stakeholder viewpoint	CSP = Cloud Service Provider, CSC = Cloud Service Consumer, CSB = Cloud Service Broker, CSD = Cloud Service Developer, USE= End-user
Validation procedure	A.A. = Axiomatic approach, A.T.M = Approach based on the Theory of Measurement, C.S. = Case study, SU. = Survey, C.E = Controlled Experiment, N.V.= Not validate, P.C. = Proof of concept

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase					Artifact evaluated				Type of service			Stakeholder viewpoint					Validation procedure						Ref. Paper		
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation			
																				Validation		Validation			Validation			
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.		P.C.	
EF FE	Productivity	Service cost	X	X			X				X			X	X	X	X							X				S14
EF FE		Access update ratio (AUR)				X	X				X	X		X	X		X	X								X		S23
EF FE		Cost					X				X			X	X												X	S15
EF FE		Cost	X	X			X		X		X	X			X	X	X										X	S08
EF FE		Price	X	X			X		X						X		X									X		S19
EF FE		Pricing	X	X			X		X		X	X	X	X	X	X	X									X		S03
EF FE		QoE		X			X				X	X			X		X										X	S04
EF FE		QoE RAS System (Ins Upd Del)	X				X				X	X		X	X		X	X								X		S23

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase							Artifact evaluated			Type of service			Stakeholder viewpoint						Validation procedure						Ref. Paper
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation			
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.	P.C.		
EFFE		QoE RAS System (Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE RAS User (Ins Upd Del)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE RAS User (Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE System R&Q (Ins Upd Del Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE System Total (Ins Upd Del Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE User R&Q (Ins Upd Del Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		QoE User Total (Ins Upd Del Sel)	X				X				X	X		X	X		X	X							X		S23	
EFFE		StateCost					X				X			X	X										X		S15	
EFFE		Successful service outcomes					X				X	X		X	X		X	X							X		S23	
EFFE		TransCost					X				X			X	X										X		S15	
EFFI		Workload delay					X				X			X	X				X				X		X		S24	
SATI	Acceptability	Flow-Short-Scale (FSS) [17] or the Flow State Scale					X				X	X			X		X		X						X		S18	
SATI	Acceptability	Game Engagement Questionnaire (GEngQ) or Immersive Experience Questionnaire (IEQ)					X				X	X			X		X		X			X			X		S18	

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase							Artifact evaluated			Type of service			Stakeholder viewpoint					Validation procedure						Ref. Paper
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation		
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.	P.C.	
SATI	Acceptability	Game Experience Questionnaire (GEQ) or in-game version (iGEQ)					X				X	X			X		X		X						X		S18
SATI	Acceptability	Igroup Presence Questionnaire (IPQ)					X				X	X			X		X		X						X		S18
SATI	Acceptability	Player Experience of Satisfaction (PENS)					X				X	X			X		X		X						X		S18
SATI	Acceptability	Presence Questionnaire (PQ)					X				X	X			X		X		X						X		S18
SATI	Acceptability	Self-Assessment Manikin (SAM)					X				X	X			X		X		X						X		S18
SATI	Courtesy	Degrees of formalization of the employee's language and attitude (DoF-ATT)	X						X			X	X	X					X							X	S33
SATI	Courtesy	Free trial		X		X	X				X	X	X	X	X	X	X								X		S03
SATI	Pleasure	API		X	X	X	X		X		X	X	X	X	X	X	X								X		S03
SATI	Pleasure	Client interface		X	X	X	X		X		X	X	X	X	X	X	X								X		S03
SATI	Pleasure	Use Intention		X			X				X			X	X	X	X						X				S10
SATI	Pleasure	User Experience Level	X	X			X				X	X	X	X	X	X	X								X		S03
SATI	Pleasure	User patient					X				X			X	X				X						X		S07
SATI	Responsiveness	Delay Score					X				X	X			X		X								X		S04
SATI	Responsiveness	Game delay (GD)					X				X	X							X						X		S06

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase							Artifact evaluated			Type of service			Stakeholder viewpoint					Validation procedure							Ref. Paper
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation			
																				A.A.		C.E.			N.V.			
																				A.T.M.		C.S.	SU.	P.C.				
SATI	Responsiveness	Network (ND)	delay				X				X	X								X						X	S06	
SATI	Responsiveness	Playout delay (OD)					X				X	X								X						X	S06	
SATI	Responsiveness	Processing (PD)	delay				X				X	X								X						X	S06	
SATI	Responsiveness	Response (RD)	Delay				X				X	X								X						X	S06	
SATI	Responsiveness	Responsiveness (RESP)					X				X	X	X							X						X	S32	
SATI	Responsiveness	Responsiveness (RESP-CQ)					X				X	X	X	X						X						X	S31	
SATI	Responsiveness	Responsiveness(R)		X	X						X			X					X	X						X	S05	
SATI	Trust	Cloud Customer Confidence Level					X				X	X			X											X	S21	
SATI	Trust	Monitoring		X	X		X		X		X	X	X	X	X	X	X								X		S03	
SATI	Trust	Monitoring		X	X						X			X		X	X								X		S02	
SATI	Trust	Number of Clients		X							X	X							X						X		S01	
SATI	Trust	Perceived fluidity of gameplay (ACR scale)					X				X	X							X							X	S22	
SATI	Trust	Perceived graphics quality (ACR scale)					X				X	X							X							X	S22	
SATI	Trust	Reliability (Rel)					X				X			X	X		X								X		S28	
SATI	Trust	Reputation		X	X		X				X	X	X	X	X	X	X								X		S03	
SATI	Trust	Reputation					X				X			X	X				X						X		S29	

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase						Artifact evaluated			Type of service			Stakeholder viewpoint						Validation procedure						Ref. Paper	
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation			
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.	P.C.		
SATI	Trust	Reputation of service provider	X	X							X			X		X	X		X							X		S02
SATI	Trust	Reputation (Repws)						X			X	X							X							X		S09
SATI	Trust	Security (Sec)						X			X			X	X		X									X		S28
SATI	Trust	Transparency		X							X			X			X		X							X		S11
SATI	Trust	Trust						X			X	X	X	X					X							X		S25
SATI	Trust	Trustworthiness of service		X							X	X							X								X	S17
SATI	Trust	Trustworthiness of virtual resources and services						X			X	X	X	X					X							X		S30
SATI	Trust	Utility of trust for request (Ti)						X			X			X	X		X		X							X		S28
SATI	Trust	Video Quality Score Squality						X			X	X			X		X										X	S04
SATI	Utility	API	X	X							X			X		X	X		X							X		S02
SATI	Utility	Customer support	X	X	X	X	X		X		X	X	X	X	X	X	X									X		S03
SATI		Game Mean Opinion Score (GMOS)						X			X	X							X								X	S26
SATI		Mean opinion score (MOS)						X			X	X									X						X	S27
SATI		Mean opinion score (MOS)						X			X	X									X						X	S27
SATI		Mean opinion score (MOS)						X			X	X									X						X	S27

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase						Artifact evaluated			Type of service			Stakeholder viewpoint						Validation procedure						Ref. Paper		
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation				
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.	P.C.			
SATI		Mean opinion score (MOS)		X			X				X			X	X	X	X							X					S10
SATI		Mean opinion score (MOS)					X				X	X								X						X			S20
SATI		Satisfaction degree		X			X				X	X	X	X	X			X						X					S16
SATI		satisfaction rate					X				X				X			X						X					S14
SATI		Service Visibility					X				X	X			X					X							X		S21
SATI		User Experience	X	X							X			X		X	X			X					X				S02
SATI		User rating					X				X	X	X	X						X					X				S25
SATI		User rating					X				X	X	X	X						X					X				S25
FREE	Environmental risk	Carbon Cost (CFP)		X							X	X			X			X							X				S12
FREE	Environmental risk	Data Center Infrastructure Efficiency (DCIE)		X							X			X				X							X				S11
FREE	Environmental risk	Data Center Performance per Energy (DPPE)		X							X			X				X							X				S11
FREE	Environmental risk	Efficiency of the physical infrastructure (PUE)		X							X			X				X							X				S11
FREE	Environmental risk	IT equipment energy efficiency (ITEE)		X							X			X				X							X				S11
FREE	Environmental risk	IT equipment utilization (ITEU)		X							X			X				X							X				S11

Quality of experience metrics for cloud services: A systematic mapping

QoE characteristic	Sub-characteristic	Metric	Lifecycle phase						Artifact evaluated			Type of service			Stakeholder viewpoint						Validation procedure						Ref. Paper
			Req.	Acq.	Dev.	Int.	Ope.	Ret.	Spe.	Arc.	Ser.	SaaS	PaaS	IaaS	CSP	CSB	CSC	CSD	USE	Theoretical Validation		Empirical Validation			No Validation		
																				A.A.	A.T.M.	C.E.	C.S.	SU.	N.V.	P.C.	
FREE	Environmental risk	Penetration of renewable (green) energy into the system (GEC)		X							X			X			X								X		S11
FREE	Environmental risk	Power Usage Efficiency (PUE)		X							X			X			X								X		S11
FREE	Environmental risk	Service Sustainability(E)		X							X	X			X		X								X		S12
COCO	Flexibility	Flexible Capacity (C)					X				X		X		X										X		S21
COCO	Flexibility	Flexible Degree					X				X		X		X										X		S21
COCO	Flexibility	Flexible Distance (Si)					X				X		X		X										X		S21
COCO	Flexibility	Flexible Force (Fi)					X				X		X		X										X		S21
COCO	Flexibility	Flexible Point (FXPi)					X				X		X		X										X		S21
COCO	Flexibility	Payment flexibility					X				X	X	X	X						X					X		S25
COCO		User Experience Level					X				X	X			X		X								X		S13