Evaluation of Ubiquitous Computing Systems: Exercise in Frustration or Research Opportunities?



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A division of Intel Labs

Announcements

- 3 conferences in ubicomp/pervasive computing
 - Pervasive 2002: www.pervasive2002.org, Zurich, August 26 – 28
 - Ubicomp 2002: www.ubicomp.org, Goteburg, Sept. 29 – Oct. 1
 - IEEE Pervasive Computing: www.percom.org, Dallas, March 23 – 26 (October 1)
- Doctoral Consortium
- Lots of workshops and specialized conferences
- Previous Ubicomp Seminar
 - Abstract book
 - Report





Outline

- Evaluation
 - What it is
 - Why it's good for you
- Overview of evaluation
- Types of evaluation and examples



What is Evaluation?

- Appraisal of the value of a system
- Examining a system to determine extent to which certain properties are present



4 Reasons Why Evaluation is Your Friend



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Why is it good for you?

- Necessary for validating your ideas – Needed for any research project: thesis
- Know when to stop
 - Have a hypothesis and need to know that it's true (or false)
- Compare others work to your own
- Compare others work against each other



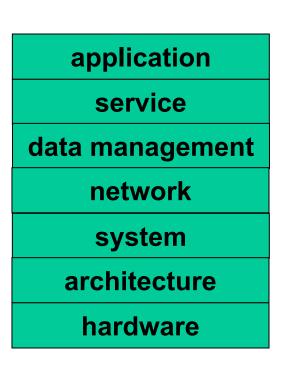
Types of Evaluation

- Quantitative
- Qualitative

Formative

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Summative





Few Differences with Ubicomp

- What is transparent?
- Implications of transparency
- Living with system critical mass needed?
- Failure recovery/graceful degradation
- Evolvability
- Scalability
- Garbage collection at many levels
- Cost not just dollars, but computational resources, battery power, bandwidth, devices, infrastructure needed





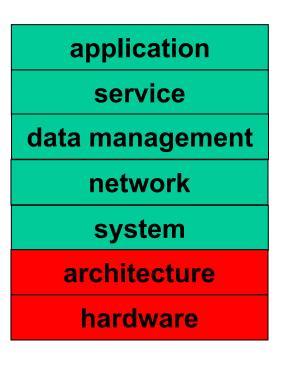
Example System

Pick on someone



Hardware and architecture

- Interference
 between devices
- Resource scheduling
- Device usability





Distributed Computing: Systems/Networking Evaluation

- Bandwidth constraints
- Connectivity
- Performance

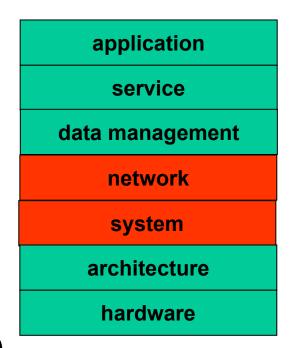
application
service
data management
network
system
architecture
hardware



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Distributed Computing: Systems/Networking Evaluation

- New functionality: qualitative
 - does it perform the job you wanted it to do?
- Improving functionality: quantitative
 - Throughput, latency (Hannes), speed, power usage
 - Bigger, smaller, faster, more efficient, more accurate (Jan)
 - Comparable results, but with fewer assumptions/restrictions (Kulpreet)
 - Simulation accepted methodology





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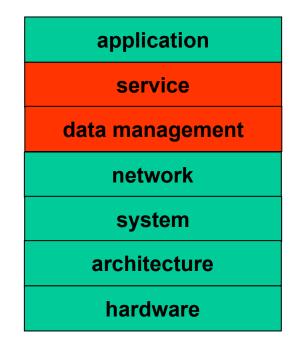
Distributed Computing: Systems/Networking Evaluation

- Differences with ubicomp
 - What are they?
 - More nodes
 - Greater latency
 - ???
 - Harder to simulate
 - What else?
 - Can we use the same techniques as before?



- New functionality
 qualitative
- Enhanced functionality
 - qualitative and quantitative

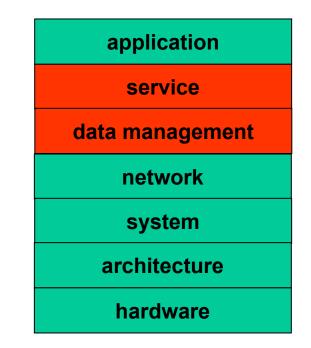
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- Correct decomposition into services
- Communications
- Reliability
- Latency in service discovery



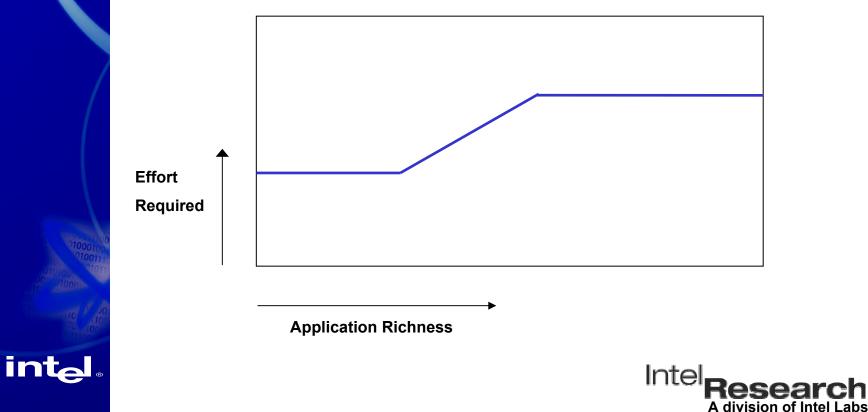






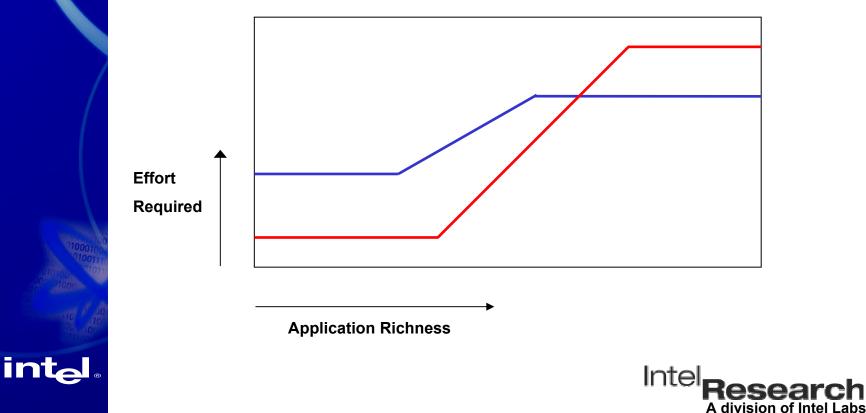
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Floors and ceilings





Floors and ceilings





- My approach
 - Lower the floor: rebuild existing apps, but show it's *easier* (user modeling app)
 - Raise the ceiling: build new, *difficult* to build apps (Thomas)



- If you build it, they will come (John)
- Explore the design space





- Differences with ubicomp – Not too much
 - Increased complexity
 - Increased constraints
 - -???

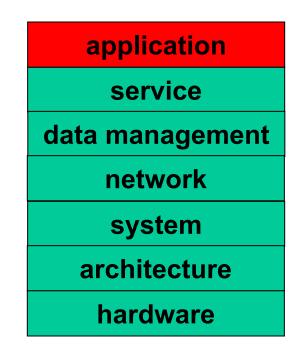




Applications

 Task focused: qualitative and quantitative

 Non-task focused: *qualitative* and quantitative





Applications

- Done today:
 - Quantitative: objective
 - Completion times, accuracy
 - Instrumentation
 - Qualitative: subjective
 - What users think: happier, more efficient
 - Questionnaires, interviews, monitor
 - Table of techniques



Applications

- Useful, usable
- Interesting/fun
- Predictability and mental model
- Forgiving system: recovery
- Bleeding edge technology
- Novelty
- Unanticipated uses
- Quantitative metrics



Applications: Ubicomp Differences



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here: human vs. network performance





Applications: Ubicomp Differences

- Monitoring duration
- Time to get used to technology: remove the "wow" factor
- Often interested in the infrequent odd cases
- Not always solving today's problems: comparison points



Applications: Monitoring

-Real world: hard to monitor

– Is an environment with cameras, microphones, computers capturing information about users and interactions a ubicomp system?

-YES!



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Applications: Monitoring

- Existing monitoring setups are ubicomp environments
- Setup even more complex for monitoring distributed, mobile ubicomp apps
- Have to build a ubicomp system to evaluate your ubicomp system!
 - Chicken and egg problem



Applications: Techniques

• Formative:

- Beeper studies: want to know what users are thinking (directly)
- Look for patterns: want to know what users are thinking (indirectly)

Summative:

- Task oriented: lab studies
- Living laboratory
- Modifying existing evaluation techniques



Examples

- Star Trek doors
 - Why such a hard design problem
 - Leads to hard evaluation problem
- Classroom 2000 & Aware Home
 - Living Laboratory
 - Longitudinal studies
 - Demo
- Ambient displays



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Ambient Displays (Dey, Mankoff and many students) •Peripheral cues of some (potentially) interesting event in your environment

•Any modality: listen, feel, smell, see, taste

•Typically abstracted information

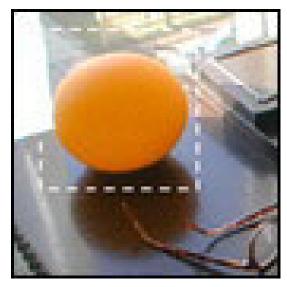
 Use perceptual channels that aren't already overloaded

Provide awareness through everyday objects



Innovative Ambient Displays

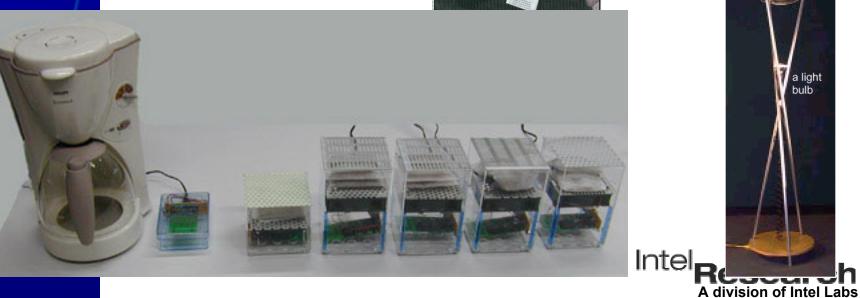
(many others)







a light bulb





Interesting Issues

- Explore the design space: toolkit, individual examples
- Provide information that is *relevant* to a space or a group of people
- Do it in an interesting/provocative/aesthetic way
 - Transitions: overview to specific; static to interactive
 - Enhance everyday artifacts
- Have some way of measuring the results Intel Research

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Design Space Exploration

- Aesthetics
- Obtrusiveness
- Notification
- Persistence
- Temporal context
- Overview to detail transition

- Audience
- Modality
- Level of abstraction
- Interactivity
- Location
- Content



Relevant Information

- Contextually dependent
- Looked at needs of small and large workgroups in university settings
- Starting to look at health:
 - Individual health of an elderly person
 - Aggregate health of a city



Interesting Displays

- Tied to relevance of information
- Aesthetically pleasing
- Displays that both blend into the user's environment when not needed and pop out when desired



Evaluation

- Change people's awareness of information
- Change people's behavior
- Existing techniques don't seem appropriate
 - Meant for focused tasks
- Modify existing techniques



Our Ambient Displays

8-II.a/ 15-II.a/	22-IIa/ 30-IIa/	05-10 13-10	20-10 27-10	D5-J11 12-J11	19-10 25-10	02-Att 09-Att	15-810 23-810	30-And DT-Sep	20-Sep 27-Sep	D4-Oct 11-Oct	18-Oct 25-Oct	D1-Nos 10:00	10:30 11:00	11:30 12:00	12:30 11
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MIRA:0270.2	MCBI:0077.9	HESC:00130	NUTC: 0164.4	USSN: IDES 2	N/6/1:0020.5	NUCTORSO	NTEC: DI96.6	NYHC:00163	OPHII:0048.5	PAGE COST 8	PENG:0284.7	FLCC: 0021.9	PROC:0033	PTEC:0317.1	OSFT:22
LINSN: 1.555.	IICCC:2.119.	HETA:0015	HUAN:0005	NGTR:00659	NAVE:0027.7	NIIC	NTES: 0025.6	NYUX:0057.6	OFLICE465.1	FALU: 2.551.	PENN:0465.1	PLCE: 0727	PRCH:00537	PTEK DI95.5	QSILD
LX8K0117.8	HCCL:0052	HETB:0017.8	MUPT:0097.8	NTCH:DIDT.1	NED: 1.423.	NMGC:00960	NTEY:002.6	NZYM:00228	OPMR:0513.3	PANL DISD.4	PENX:0097.9	PLC M: 3070.	PRCP:00119	PTEN: 1.ST4.	QSND:00
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LYTS:0261.4			MNDO:0035.0 MNRO:0132.0	MTGN_0000	N8T8:0345.5	NHPS:007.7	NTIQ: 1,831, NTLO: 0211.7	0A0T:0048.8 0ATS:0245.5	OPTI: DUST.1	PARS: U1245 PATH: USU2.3	PERV:00522	PLNR:0305.7	PREM:00093	PTMK DT 45.7	QUIP:00
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MACE:00247	IICHP: 5,252.	MFBC:0029.8	MNTE:0007.9	MTDC 0080.1	NC EH:0017.2	NUTC:0874.8	NTO P:0333.1	0801:0005.5	OPTN: 0231.7	PATR:00739	PETD:0096.7	PLSIC 0062.1	PRFC:04018	PTRO:0001.0	QUST:00
UACR: 1,278.	MCIT: 1,549.	MFCO:0004.1	MNTG:0437.8	MTLC:0018.6	NC EM:0011.0	NUTI:0007.9	NTPA:0116.3	OBIE:0019.5	OPTO:0015.2	PAYX: 13,895	PETH: 1,193.	PLUG:0517.6	PRFS:0139.1	PTRS:0023.2	QVDX:05
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ADG0027.0	MCLD: D162.6	MFLR:0018.7	MOBE:0021.0	MITLK DIOT D	NCFC:00000	NHUS:0012.4	NTRS: 13,662	OCCF:0075.3	O PTV: 0548.5	PBC P:0219.1	PF8X:0000.0	PDXS: 1,113.	PRGN: 1,604.	PTSI: 0127.1	RACN:02
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ILAGS: DDT9.5	MCLS:00742	IIFRED16.8	MOCO:00507	HTUS: 0025.4	NCOG:0525.9	NNCI:0044.3	NTSC:0011.4	OCFC:0241.2	ORBK: 1,029.	P8F10014.5	PFCO:0009.0	PILACA: DID 9	PRGS:0520.4	PU88;0099.9	RADIF:00
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IIAIR:0159.3	MCSI: 0344.5	MGEN:0250.2	HOIL:0101.3	MTRO_DODD	NEIB:ED20.3	NOGAF: IIII2.7	NTUD:003	ODETA: D16.5	ORCI: 0032.7	PBKB:0071/5	PFGC:1,498.	FMFG:0053.3	PRKR:0226.6	PURE:0010.4	RAGS:00
MAJR:0005.1	MCTI: 0045.0	HGIC:00519	MOLX:6,357.	IITRX: IDS4.0	NENG:00362	NO ECIDINE.3	NUAN:0291.5	ODETE: 00250	ORCL: 90,435	FBIS:0531.3	PFGI: 1,174.	PHIC:0000	PRLS:0018.4	FURW: DDF D	RAND:00
MALL:00437	IICTR: 0273.6	MGRC:0457.1	HOLXA: 2,795.	IITSC: 0215.6	NEO F: 03937	NOLD:DID20	NUCO:DID5.5	ODFL:0110.1	ORCT:0076.3	PENC:0000	PEIN:0024.2	P1110:00183	#RUX:0090.4	PVAT:0044.0	RANGY:00
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UANC:0017.9	HDBS:0000	MHCO:0036	HONE:0513.7	ITSN:0321.8	NEOL:0338.4	NOPT: 004.5	NUHC:0173.5	010:0516.4	ORFR:0004.3	PCAGEDODA	PF68:0191.3	FMRF:00127	FROG:0013.0	PVFC:0054.7	RARE:05
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MAXIC:0019.3	HOTH:0300.6	MINE0517.2	MRGO:0008.5	MXIII: 18,401	NEXL:00339	NRIII:0053.6	NUMAY: DDD5.8	OMNI:0033.4	OTEX:0593.3	PCTED2025	PHU:0020.0	POCC:0049.0	PRVD:0014.0	PZZI:0014.8	REOM:00
MAXE:0038.1	MDTL:0130.4	11 19 6: 0483.6	MRNT: 1,165.	MXRE: DSSS.D	NEXU:0081.5	NRRD:0074.4	NUMB T: DDB3.1	OMTL:0098	OTFC:0000.4	PCTV:0119.5	PHLY:0715.7	POCIEDUTS	PRVT:0413.1	QADI:0110.2	REPAA:01
MAXE:0040.8	HD00/:0014.9	MIPSB: D441.6	MROE:00659	IID00L:0102.1	NEXT:0070.3	NSANY: 14,290	NUIFE 0045.7	ONCO:01542	OTGS:039.5	PCYC:0158.8	PHMD:0035.4	POLXF:0008.3	PRXL:0346.7	QBAK(IIIS3.6	RCCC:02
JAXUI:0148.1	MEAD:0055.0	MITK 0019.8	MRO1:0518.7	HYG N: 1,096.	NFLD:0128.0	NSAT:0053.6	NV/FL:00450	ONCY:0000	OTRK8:0886.9	PDCO:2719.	PHOC:00039	POID L: 0665.3	PSAI:0066.4	QC8C:01452	RCII:12
LANS: 01458	ILEDC: 0247.4	HITSY:7,530.	MRSA:0005.5	UVST:0023.2	NGAS:0003.5	NSCN: 1,783.	NV/IR:0014.7	OND1:0085.3	OTTR: 0554,7	PDEX:007.8	PHON:0003.3	PO PEZ:0051.1	PS81:0018.9	0COH:35,553	RC KY:00
ILAXY: 0535.4	MEDI: 10,045	MITY:0047.5	MRTI:0010.6	NABI: 0365.0	NGEN:0112.6	NGDA:0403.5	NOLIA:0353.2	ONES:01307	OTINO:0043.6	PDFS:04120	PHG8:0039.8	FORT: DISS.7	PSC D:0022.9	QCRH:0017.3	RC IIT:00
MAYS:00252	HEDH:0070.5	MHE:0048.4	MRTN:0015.1	NADX: 0085.6	NGPS:00169	NSD 8:0054.0	NVILL:000.4	ONEV:009.6	OUS8:0001.1	PDGM:0123.7	PHST:0032.1	POSO: DIST.S	PSCO:0018	QDEL:0254.2	RCNC:02
II.AZL:0022.3	IEDQ: 1,113.	MHSt 1050.	MRVC:0359.9	NAFC:0350.4	NGRU:0038.6	NSEC:0039.6	NUMPX:0114.0	ONFC:0080.5	OUTL:0016.5	PD II: 0285.2	PHSY:0572.5	POSS:0314.1	PSCX:007.3	QDIN:0025.5	RCOM:04
UBAY:0011.3	ILEDS: 0018.8	MIKTAY:0004.8	MRVL: 4,765.	NAI: 0013.5	NHCH:0169.3	NSFC:0096.4	NARE:00752	ONIS: DOT 4.4	OVEC:0076.0	PDLI: 2,531.	PHTN:0582.5	POVT:0021.6	PSEM:0378.3	QEKG:0176.9	RCOT:05
UBBC:00510	ILEDWI: DD27.6	IIKTG:DIS.4	MRVT:01820	NANO: 0258.3	NHCLODID.1	NSIL:0051.8	NU098:0534.1	ONNN:0555.5	OVER: 1,968.	PDLPY:0522.4	PHYX:0016.5	PCIMI: 0594.0	PSFC:0018.8	QEPC:0016.4	RDCM:00
HBF1:0222.9	HEDX: 1,202.	MIKTOR: DDS8.0	MRXX:0008.8	NANX:00859	NHHC:0008	NSIT: 1,008.	NXCD:0023.5	ONPR:007.3	OVRL: DIST.S	PDSG:0016.7	PICO:0161.2	FORUL: D2DE.D	PSFT: 12,190	QFA8:0134.6	RDEN:03
HEHI:0223.5	# BGO:0016.5	#KTY:0122.2	MRYP:0019.0	NARA:0103.0	NHT8:00008	NSPR:0007.3	NXRA:0013.8	ONSP:00012	OV/TI: 0245.1	PDYN:0191.0	PIII:01129	POZN:0138.4	PSIT:0120.6	QGENF:2.989.	RORT:08
118LA:0018.3	#EMH:0153.3	BLAB:00212	MSBF:0014.0	NASE:0139.9	NI4G:0013.4	NSSC:0020.6	NXTL:7,983.	ONSS:00182	00/05:002.1	PEAK DIDSS	PILL:0030.3	PPCO:0280.9	PSHT:0221.8	QGLY:INT.6	ROTA:00
UBNICO1637	MENT: 1,708.	ILAN:0730	MSBICDIT4.5	NASE DIST.3	NICE:0100.4	NSSI:0012.2	NXTP: 2,365.	ONTC:0048.4	OUMAN: 0021.4	PERKIDIAS	PIDS:0415.7	PPDI: 1,615.	PSON:0014.6	QLGC: 5,225.	ROWNED
UBRS:02339	MEDH:0911.4	HLHR: 1286.	MSCC:0751.4	NATH: 0025.3	NICH:0055	NSTIC D127.4	NXTV: D255.8	ONTR:0010.3	0X3 N:0030.1	PEBO:0135.1	PDXR: 1.714.	PPHM:0289.5	PSSL0584.7	QUNX:00059	RDVIR:02
18RIV:00040	MER8:00369	MUN:0034.0	MSEL:00130	NATE 2,139.	NICKODI9.1	NSYS:0015.4	NXUS:0025.3	ONVI:0045.6	OVOG:00760	PECS:0923.5	PDCT:0016.3	PPRO:0073.1	PSTA:00965	QLTI: 1.670.	REAL:00
	MERC D125.7	ILNKCIIIIS	MSEC.00130 MSEX:0178.6	NATIC 2,135.	NIKU:0182.9	NTAI:0169.8	NICCE 0025.6	ONXS:0184.4	OZRICDIDI.6	PEDE:00220	PHOH:0026.7	PPRO: DDB.S	PSTR.00905 PSTF:0018.4	QHIDC:0269.9	REBC:01
NEW 1:0092.1	MERQ: 3,024.	HENRICHUNS				NTAP: 1.457.	NYCE:252	ONXX:0022	PAAS: D162.4	FEET:0099.2	PROH:0006.0	FOUE: DISD.8	PSTED3015	QURKIDD4D	RECN:DS
MCAP: 1.531.	MERX: 0244.0	MURC:00312	MSFT: 369,51 MSLV:0304.4	NATR: 0195.4 NAUT: 0447.8	NIPNY: 16,014	NTBICEDES:5	NVER:0008.1	ONYX:0024.4	PACT: DD2.4	PEGA:0190.9	PKTR:0218.4	PRIC:0093	PSUN:0718.4		REDF:00
					NITE: 1,554.									QRSI:0230.1	



A X

0.000	METH8:0330.8	MNRO:0132.0	MTGN00000	N8TY:0714.3	NURX:0085.9	NTLO:0211.7	OATS: 0246.5	OPTI:0037.1	PATH:0802.3	PER
1:0091.2	MEXP:0015.6	MNRTDD66.5	MTIC:0064.3	NC E8:0050.9	NMSS:01749	NTOL:0034.3	08AS:0038.8	OPTK DDB.7	PATIC DDB5.8	PE
P:5,252.	MF8C:0029.8	MNTE:0007.9	MTDC:0080.1	NCEH:0017.2	NMTC:0874.8	NTO P:0333.1	0801:0005.5	OPTN:0231.7	PATR:00739	PET
r: 1,649.	MECO:0004.1	UNTG: 0437.8	MTLC:0018.6	NCEN:0011.0	N M T1: 0097-9	NTPA:0115.3	OBIE:0019.5	OPTO:0015.2	PAYX: 13,855	PETI
0:0007.6	MFLO:0173.7	MNTR:0584.0	MTLG:0043.7	NC EN:0208.8	NMTX:0074.5	NTRO:0186.3	0CAS:0958.3	OPTS:0012.4	P8C1:0067.S	PEI
0:0162,6	MFLR:0018.7	MOBE: 00210	MTLK DIOT D	NCFC:0000	NIUS:0012.4	NTRS: 13,662	OCCF:0075.3	OPTV:0548.5	PBC P:0219.1	PFB
1:0005.9	MENX:0316.1	1081:0060.S	MTNC:0089	NC.NX:0105.3	NNBR:0161.6	NTRT: 0529.2	OCENY:0902.6	O PWW: 1,725.	PBCT: 1,308.	PEC
S:00742	MFRED15.8	MOCO:0050.7	MTUS:0025.4	NCOG:0625.9	NNC1:0044.3	NTSC:0011.4	OCFC:02412	ORBK 1,029.	P8F1:0014.5	PFC
1:0072.4	MFSF:0117.9	NOD:07880	MTNT:0013.1	NCPH:III72.6	NNDS: 1,025.	NTSL:0105.7	OCHS:0000	ORIT:0005.4	PBHC:0038.0	PFD
L:2,512.	MFUN:0007.0	NODT:0130.6	MTON:0725.7	NCREED419	NO 8 H:0035.4	NTST:0012.0	00LR:0530.9	ORCC:0025	PBCX:0077.2	PFE
S: 0490.0	MGAM:0227.5	HOGN:0372.6	MTRO0233.6	NDSN:0872.7	NOBL:0060.8	NTIME DEN.1	OCPI:0424.3	ORCH:01739	PBIZ:0017.5	PFF
1:0344.5	MGEN:0260.2	MOIL:0101.3	MTRODODD	NEI8;0020,3	NOGAF:002,7	NTWO:009.3	ODETA: III 15.5	ORC1:0032.7	PBK8:0071.6	PEG
1:0046.0	MGIC:0050.9	MOLX:6,387.	MTRX:0064.0	NENG:0036.2	NO E: DE18.3	NUAN:0291.5	ODET1:0025.0	ORCL:90,488	PBI-S:0531.3	PFC
2:0273,6	MGRC:0457.1	HOLXA: 2,795.	MTSC:0215.5	NEO F: 0393.7	NOLD:01020	NUCO:0105.5	ODFL:0110.1	ORCT:00763	PENC:0000	PFI
C0179.9	MGRP:0004.9	NOND:0602.2	MTSL:0007.1	NEOG:0098:1	NOOF:0062.4	NUFO:0334.0	ODSY:0316.8	OREC01127	PBTC:07959	PEN
S: 00000	MHCO:00056	NONE:0673.7	MTSN:0321.8	NEOL:0338.4	NOPT:0034.8	NUHC:0173.5	OFD::0516.4	ORFR:0004.3	PCAG:0030.4	PFS
A: 0077.8	MHLX:0000	MONI: 1,709.	MTSX:0000	NEOM: DD2.3	NOVA: 0034.4	NURM:00530	OGLE:III73.5	ORLY: 1,555.	PCAR: 4,787.	PFS
0:0311.6	МНИУ:0005.1	MONU:0004.6	MTWV:0190.4	N 60T:0067.0	NOV8:0066.5	NUTR:00532	OGNC:0027.9	ORPH:01232	PC 81:0034.7	PFSt
1:0152.9	MHUT:0163.5	MOSY:0626.6	MITXC:0069.0	NERAY:0265.5	NOVI:0011.2	NVAL: 0089.0	OGSI:04189	ORTC:0054.5	PCBICID57.9	PGB
0:0418.2	MICC:0515.2	MOVI: 0455.1	MUEL:0034.5	NERX:0142.8	NOVL: 1,887.	NVAX: 0259.8	0100:00180	ORYX:0099.4	PCCC:03728	PGLA
S:0005.4	MICT:0148.7	MOYC:0011.2	MUSE: 1,072.	NESY:0055.6	NOVN:0391.9	NVDA:9,118.	011111:0795.4	OS8C:0225.5	PCC1:0059.3	PGL
A: 0028.4	MIDD:0058.6	MPET:0019.5	MV81:0364.9	NETA: 4,139.	NOVT:0185.0	NVDC:0004.8	01/58:0110.1	OSCA:0255.5	PCDI: 0017.2	PGN
11:0074.0	MIEC:0535.9	MPML:0010.6	MVC0:0069	NETE: 0537.8	NP8C:04730	NVDM:0221.0	OLA8:00119	OSIP: 1,694,	PCHM:0007.2	PGT
0:0010.4	MIHL:0323.6	MP/0G:0022.3	MVIS: 0165.7	NETM:007.5	NPLS:0034.2	NVGN:000.1	OLD8:1,504.	0919:0148.8	PC IS: 0083.9	PHA
.1:0014.8	MIKN:0094.8	MPWR:0029.1	MVSN: 1,705.	NETP:0057.2	NPRO:0308.5	NVIC:0002.8	01GC:0179.5	OSKY:0044.5	PCLE: 0497.6	PHC
CIII17.5	MIKR:0011.8	WRAE:0553.5	MUNAV: 0032.4	NETZ:0007.0	NPSI:0249.4	NVLD:0097.6	OLG R:0016.4	OSTE:0111.6	POLN: 1,234.	PHE
C:0121.6	MIL8:0008.0	MR8A:0072.2	MING P: 0150.8	N BAC:0004.2	NPSP: 1,012.	NVLS: 6,164.	010G:0368.5	0STX:0037.1	PCNTF:0036.6	PHEL
at: 00034.7	MILT:0009.0	MR8K 3,105.	MWRIC 0059	NEWH:0115.5	NRC1:0052.9	NVIII1:0051.0	ONCL:0172.4	OSUR:04359	PCOM:0025.7	PHF
4:0424.5	MINS:0466.0	MRCY:0764.0	MX81F:0154.0	N B/0P: 0893.1	NRGN:0283.4	NVTL:0009.3	OMED:0018:1	OTCM:0132.9	PCO P:0332.4	PHG
r:0360.S	MIND:0041.8	MRGE: DB5.3	MXICY: 0268.4	NEWRDDD5.5	NRGY:0153.7	NUMAC: 1,553.	O M EF: 0269.2	OTEC:0194.8	PCSA:0444.9	PHHI
1:0300.6	MIN1:0517.2	MRGO:008.5	MXIM: 18,401	NEXL:00339	NRIM:0083.6	NUWAY: DDD5.8	O MNI: 0033.4	OTEX:0593.3	PCTI: 0202.5	PH
L:0130.4	MIPS:0483.6	MRNT: 1,165.	MXRE: 0655.0	NEXII:0081.5	NRRD:0074.4	N008T:0083.1	OMTL:0009.8	OTFC:0060.4	PCTY:0119.5	PHL
0:0014.9	MIPS8:0441.6	MROE:0065.9	MXXAVL: 0102.1	NEXT:0070.3	NSANY: 14,290	NUVEL: 0045.7	ONCO:0154.2	OTGS:059.5	PCYC:0158.8	рни
0:0056.0	ШПК 0019.8	MRO1:0518.7	MYGN: 1,095.	NFLD:0128.0	NSAT:0053.6	NWFL:0046.0	ONCY:	OTRKE:0885.9	PDCO:2,719.	PHO
01247.4	MITSY:7,530.	MRSA: DD6.5	MYST:0023.2	NGAS:00055	NSC N: 1,783.	NWIR:00147	ONDI:0085.3	OTTR: 0554.7	PDEX:0007.8	PHO
1: 10,045	MITY:0047.5	WRTI: 0010.6	NA81:0366.0	NGEN:0112.6	NSDA:0403.8	NWILIA: 0383.2	ONES:0130.7	OTWO:0043.6	PDFS:04120	PHS
1:0070.5	111/0E:0048.4	MRTN:0075.1	NADX:0085.5	NGPS:00169	NSD8:0054.0	NWLL: DOD.4	ONEV:0005	OUSA:0001.1	PDGM:0123.7	PHS
2:1,113.	MIKSI: 1,050.	MRVC:0359.9	NAPC:0350.4	NGRU:0038.6	NSEC:009.6	NWPX:0114.0	ONFC:0080.6	OUTL: D16.5	PD11:0285.2	PHS
S:0018.8	MKTAY:00048	MRVL: 4,765.	NAII:0013.5	NHCH:0169.3	NSFC:0096.4	NWRE:00752	ONIS:0974.4	OV80:0076.0	PDLI: 2,531.	PHT
0:0027.6	MIKTG: 0015.4	MRVT:0182.0	NANO:0258.3	NHC1:0010.1	NSIL:0061.8	NW058:0534.1	ONNN:0556.5	OVER: 1,968.	PDLPY:0622.4	PHY

Current Status

- Deployment complete
- Collected data
 - Questionnaires and evaluation
- Analyzing data
 - Heuristic evaluation \rightarrow new heuristics



Our Ambient Displays



Our Ambient Displays







Our Ambient Displays







Current Status

- Displays deployed and evaluation data collected
- Evaluation: Questionnaires, monitoring and instrumentation
- Results presented on Thursday





Examples

• GUIDE:

 monitoring, interviews, questionnaires, instrumentation

- Exploratorium:
 - -John?





Examples

- Precision Agriculture
 - -Working with wine
 - Evaluation





Support for the Disabled: Ambiguity in Context

- Mobile and speaking-impaired users: wheelchair-bound, speech synthesis users
- Difficulty performing everyday activities: communication







A division of Intel Labs

Support for the Disabled: Ambiguity in Context

- Hypothesis: context can improve word prediction
- Context: location, time, vocabulary, history
- Choose vocabularies and filter words based on context and recent words chosen



Support for the Disabled: Ambiguity in Context

- Proof of concept built using GPS unit and laptop
- Examining mediation strategies to correct context
- Starting evaluation of usefulness

Seq 1980											
salad		says	sandwich	sayi	ng	say					
Space	e	а	r	d	f	v					
t	0	n	I	g	k	j					
i	s	u	У	b	x	z					
h	С	р	q	0	1	2					
m	w	,		3	4	5					
Shift	•	-	:	6	7	8					
Back	Clear '		;	9	()					
	grocerie	!S		food							
sa											



Support for the Disabled: Video & Next Steps

- VIDEO
- Instrument parts of downtown Berkeley
- Instrument wheelchairs
- Support navigation
- Start evaluation tests





Dangers of Application Evaluation

- Computer scientists like to see hard science: no touchy-feely
- Novelty is hard to demonstrate and not always best way to advance field
- Hard to build a complete system, but often need to, to reasonably evaluate
- Good studies are hard to design and deploy: e.g. focus groups and consumer products



Conclusions

- When starting research project, have clear hypothesis!
- Evaluation of ubiquitous computing systems is non-trivial, but not impossible
- Open research questions
- Happy to act as a resource

