

EPSRC WINES

“a science of wired and wireless intelligent networked systems”

TIME: Transport Information Monitoring Environment

EACM: Event Architecture and Context Management

October 2005 – September 2010

www.cl.cam.ac.uk/research/time

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Oct 10th 2007



University of Cambridge Computer Laboratory

TIME-EACM Consortium

University of Cambridge Computer Laboratory (CL)

Ian Leslie, now pro-VC Research

Opera Group (middleware, access control, policy, trust)

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Digital Technology Group (formerly CUED-LCE)

Andy Hopper, Rob Harle, Alastair Beresford PDRA – EPSRC Fellow

Programming Research Group

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Signal Processing Laboratory

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Statistical Laboratory

Richard Gibbens (now CL, 3yr RA), Frank Kelly, (also DfT)

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Niki Trigoni (PhD CL, PDRA Cornell)

(PhD Antonios Skordylis + RA Alexandre Guitton)

Company Support

Project partner: BT Research, Martlesham

contact *Trevor Burbridge*

2yrs PDRA: *David Evans appointed April 2006*

Ali Beresford (RA) spent a year at Adastral Park before PhD

Letters of support from:

CMI

Greater Cambridge Partnership (E England Development Agency)

IBM Hursley (MQTT), Boeing

Boeing funded a feasibility study for TIME,

carried out by Cotares (A Jones, M. Brown, ex AT&T Research)

The research is applicable to sensor-based systems in pervasive computing environments

Our application domain in **TIME-EACM** is (urban) **Transport Monitoring** using Cambridge as a test-bed

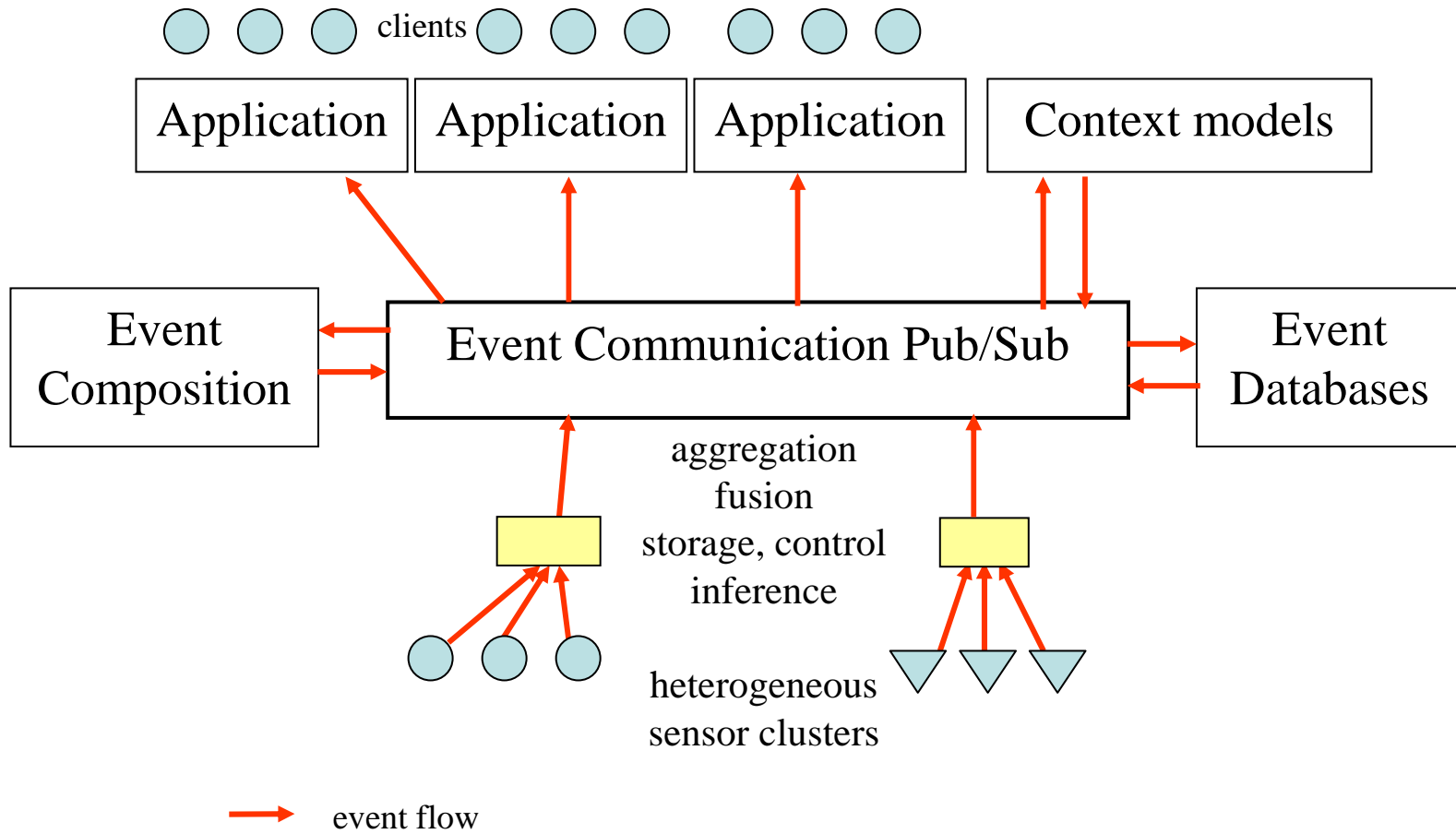
In the context of “**Energy in Cities**”

- Cambridge is mandated by central government to expand
- but is already congested and polluted
- very little real data is gathered
- *policy makers* - city and county councils - need *real data* as a basis for decisions
- *citizens* need *timely information* on transport

Research goals - summary

- to integrate heterogeneous sensor networks into a secure, event-based middleware, used by *advertise(..)*, *subscribe(..)*, *publish(..)*, *notify(..)*
- thus to facilitate application development and **data sharing**
- to study the placement within the architecture of
 - data aggregation, data cleansing, data fusion,
 - inference, correlation (pattern identification and detection), statistical analysis, prediction
- to provide high-level contexts, maps, models and active databases for users to express their interests intuitively, and be informed promptly

Integrating sensor networks - 1



Integrating sensor networks - 2

low-level data: sensor-ID, data value, timestamp, location

- value aggregation from densely deployed sensors
- inaccuracies masked – data cleansing
- heterogeneous sensor data correlated (fused)

high-level information/semantics:

- events defined, to present sensor data to applications, including context models
- events correlated, higher-level events notified
- real-time delivery may be required
- level of data logging required?

TIME-EACM example applications

1. Subscription to advertised, named *events (arguments = values)*
bus-seen-event (busID=citi4., location=MadingleyP&R-exit)*
desktop/device is pinged when a bus is detected
2. Multimode route advice e.g. CL to Stansted Airport
 - a) bus/cycle/drive (and-park?)/taxi to Cambridge railway station.
Is train from B'ham on time? – journey time?
 - b) drive down M11 – congested? Journey time?
3. City Council build 1400 new dwellings near Cambridge Station
.... monitor the effect on traffic
and see demos

Legal/Policy Issues

“buses should run to time and bus operators will incur penalties if published timetables are not met.”

so bus operators refuse to cooperate in traffic monitoring, even though monitoring could show that delay is often not their fault. This is a real constraint on making data public.

Gathered data that identifies individuals must not be stored:

CCTV cameras: software must not *recognise* people and store identities with images

(use thermal imaging (infra-red) – just count)

Vehicle number plate recognition (ANPR):

numbers must not be associated with people then stored
numbers may be recognised if displayed

(only police are allowed to look up # - name)

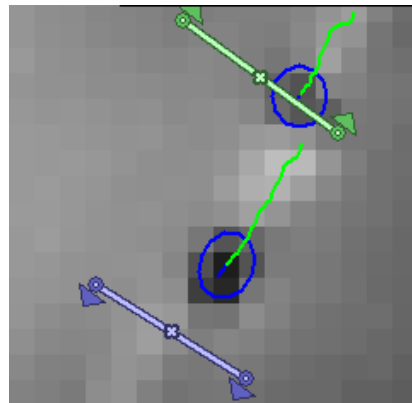
1: Traffic light control using SCOOT

- 1980s induction loop technology embedded at junctions to count queue lengths
- many junctions are no longer metricated
 - not replaced when destroyed, expensive to install
- used for localised control
 - green light for long queues, and if bus at junction
- Web-accessible, live data from Feb 2006 via Siemens
- data archived for historical analysis (only since 2006)

see demo

2. Irisys infra-red cameras + motion detection

- combined with video for validation
- privacy - preserving
- Testing carried out on Dept. Eng. roof, Fen Causeway, 2006
- ~ 90% success rate cf. video.
- wired communication via Engineering Dept.



2. Irisys – mirroring annual manual count

- carried out on Cambridge radial roads annually
- we did Huntingdon Rd, 9th Oct 2006, 8am – 7pm
- using one of DTG's sentient vans
- incoming and outgoing traffic
- validated against video
- over 90% success rate cf. video,
- if cycles excluded
- (with our *inexpert* positioning of the sensor)
- County haven't told us how their manual count compares with video



3: Stagecoach/ACIS bus monitoring

- GPS location of buses on some Stagecoach routes: 4, 7, P&R
- packet radio transfer back-to-base
- bus-stop displays (of timetables?)
- live and historical data from ACIS since Aug 2007, under a NDA
- initial project: display on city map of real-time positions
 - *see demo*
- this data allows **journey times** to be analysed

Related projects

- **MESSAGE** mobile environmental sensing system across grid environments, EPSRC e-science and DTI, 2006-9
 - Cambridge: pollution monitoring using mobile phones to augment static sensors

<http://research.cl.ncl.ac.uk/message>

- CL-DTG weather station data since 1995

www.cl.cam.ac.uk/research/DTG/weather