Research Consortium in Speckled Computing

Speckled Computing - Overview

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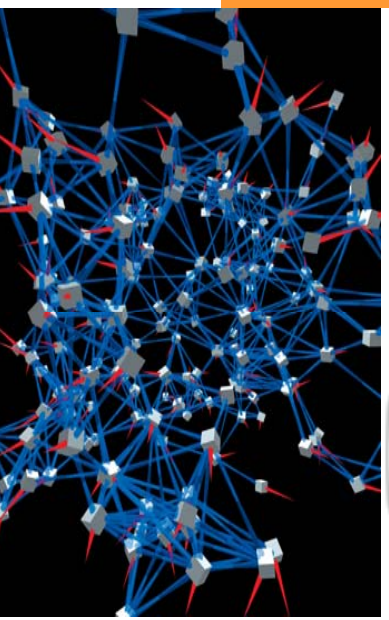
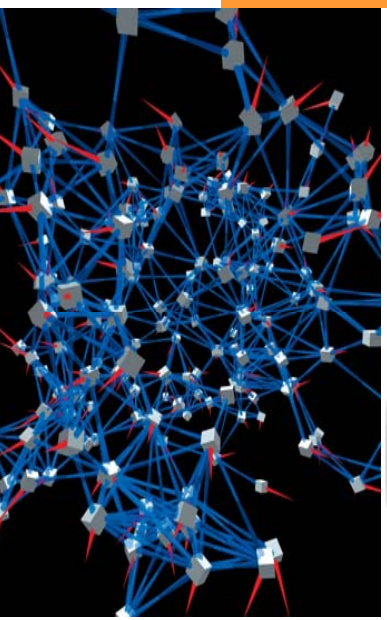
The future Internet



- The Internet is 1 Billion strong today
- The future IPv6 will support > 35 Trillion separate subnetworks
- Each sub-network, in turn, will connect millions of devices

We are moving towards a world of connectedness between people and "smart" objects

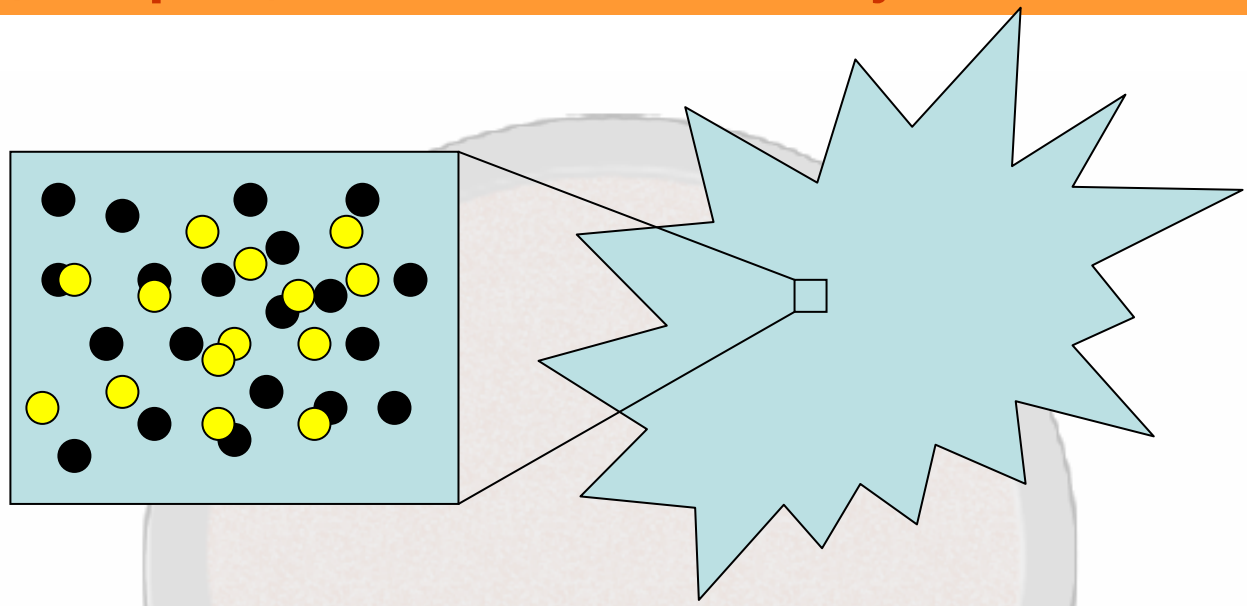
i.e. CONTEXT-SENSITIVE and LOCATION-AWARE



- Endow everyday objects with sensing, processing and wireless networking capabilities
- Link the sensory data from the physical world to the virtual world of networks of computers and the Internet

Specks bridge the physical and virtual worlds

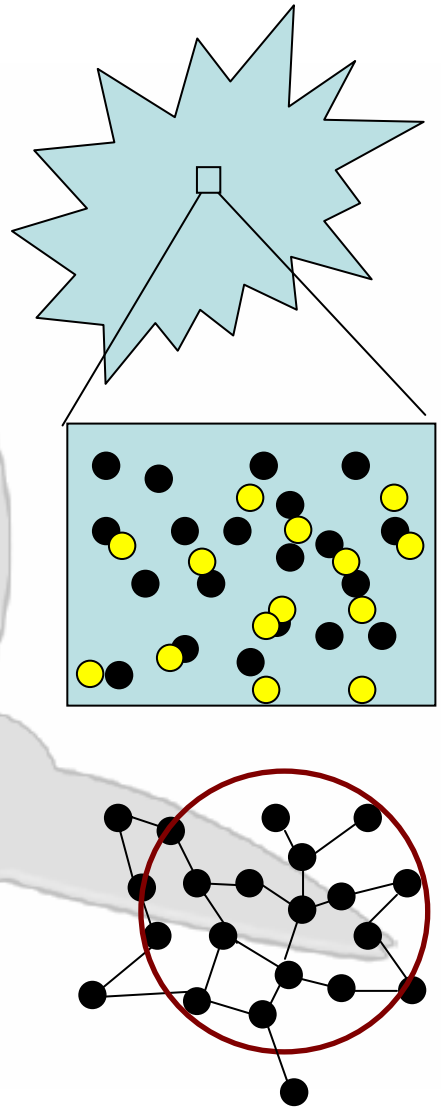
"Specks are programmable semiconductor devices which can sense, compute, and network wirelessly."



- Specks communicate wirelessly over a few cms
- Size of a matchstick head (5X5X5mm) with limited power
- Specks bought by the weight: yellow specks - temperature sensor,
  black specks - pressure sensor
- Specks are assumed to be non-static and unreliable

Specknets and Speckled Computing

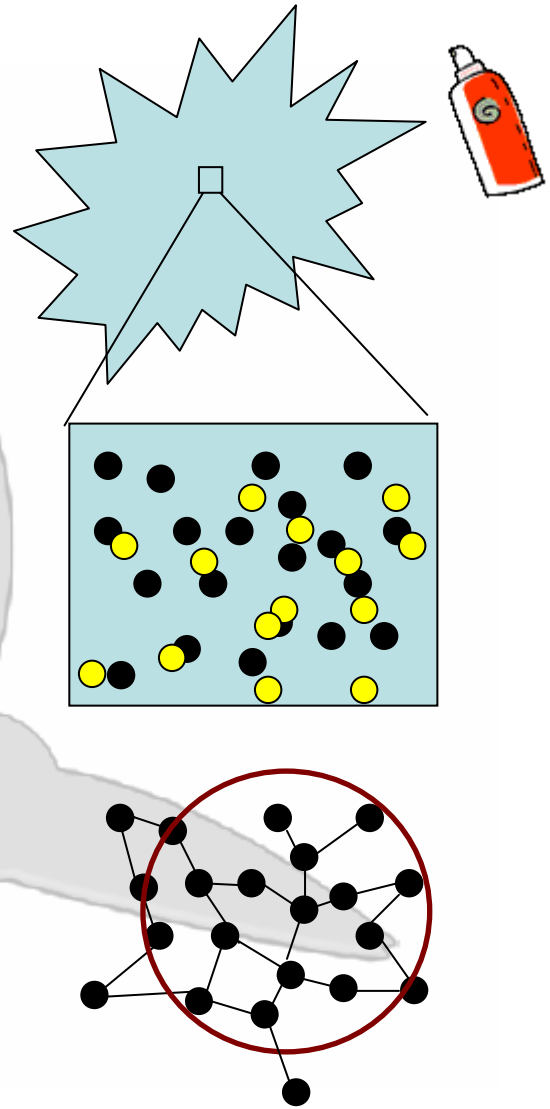
- Thousands of specks collaborate as dense programmable network – Specknet
- Sensory data processed collaboratively, and information extracted *in situ* – fine-grained distributed computation
- Encapsulation of sensing, processing and wireless networking in a single chip



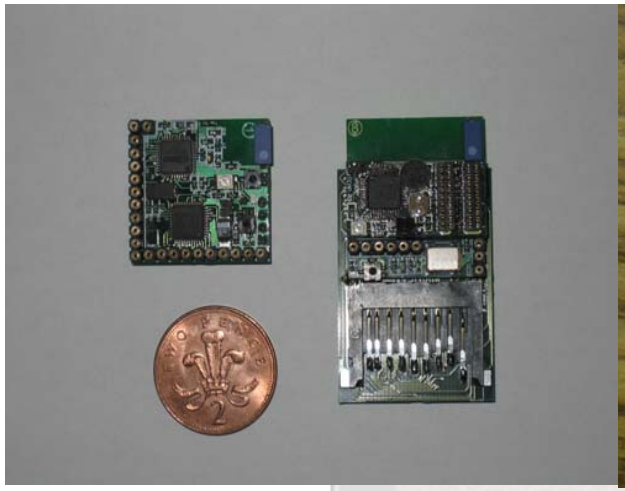
Enabler technology for ubiquitous computing

Specknets - Looking Beyond Traditional Sensor Networks

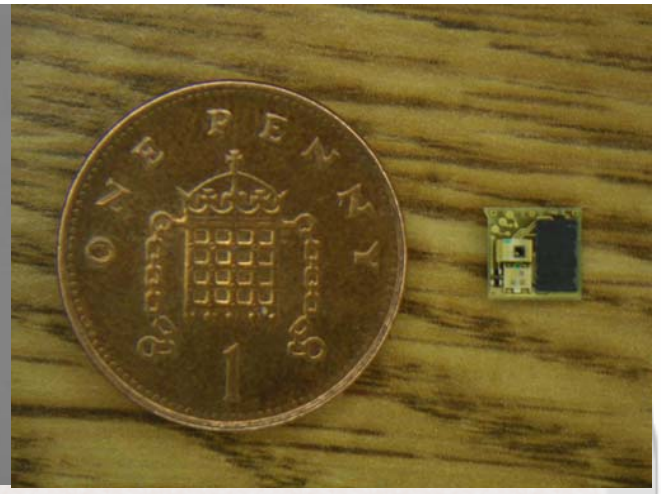
- Program-centric (specknets) v/s data-centric (sensor networks)
- Sparse (sensor networks) v/s Dense networks (specknets) – short range comms
- Mobility model – nodes in sensor networks are static. In contrast, specks are mobile
- Data transfer model – Source nodes transfer to sink nodes (sensor networks) v/s peer-to-peer model in specknets
- Control model - Decentralised, leaderless



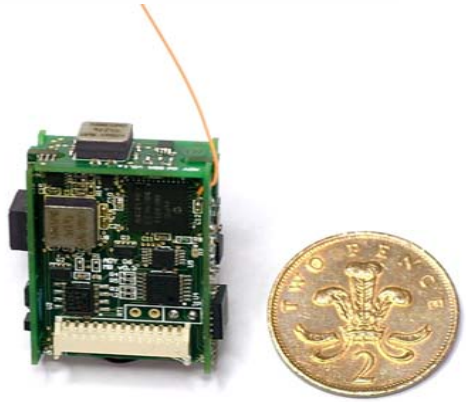
Classes of Specks



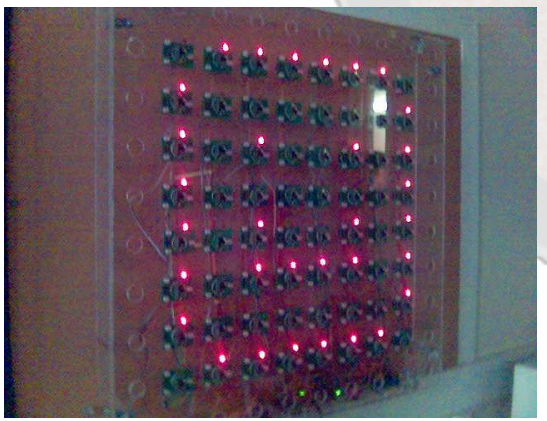
8-bit (med) client
32-bit (large) microserver

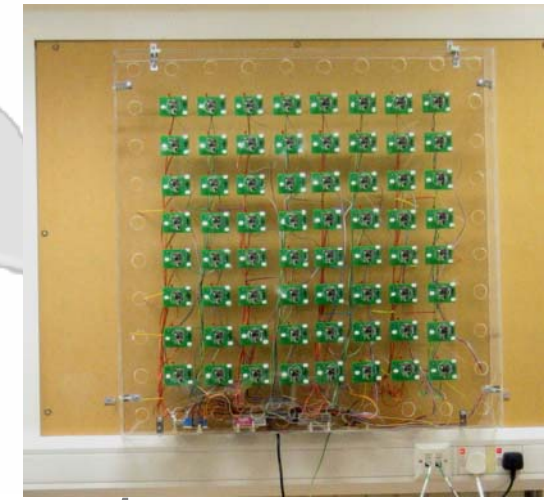


8-bit 5mm cube client



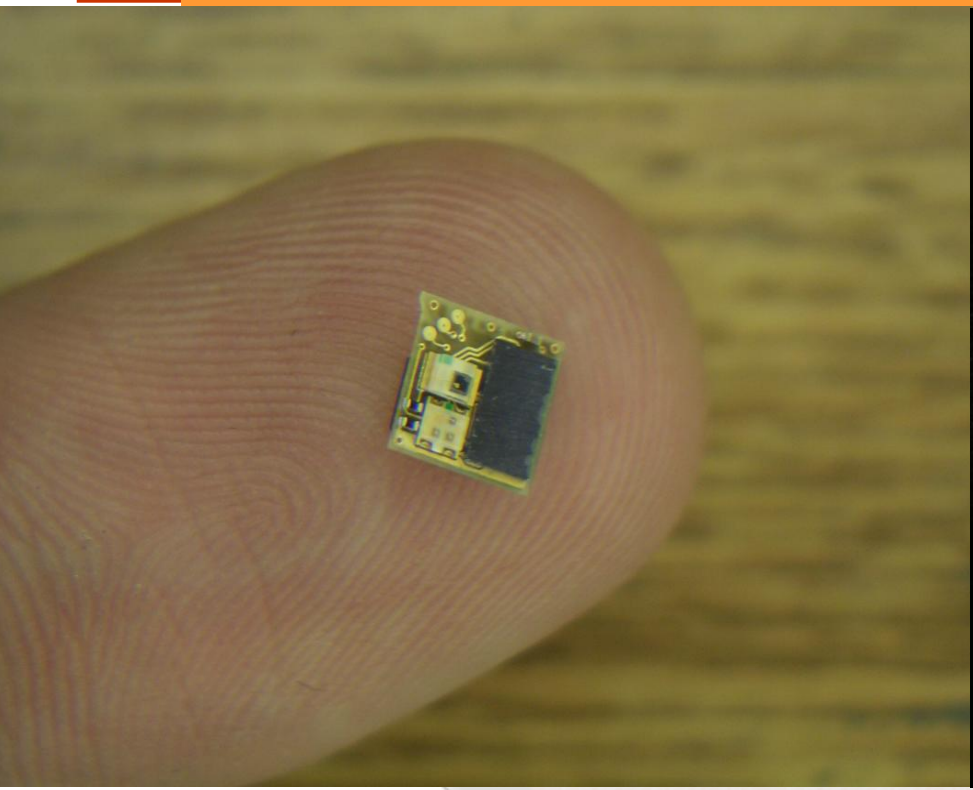
Orient2 Speck

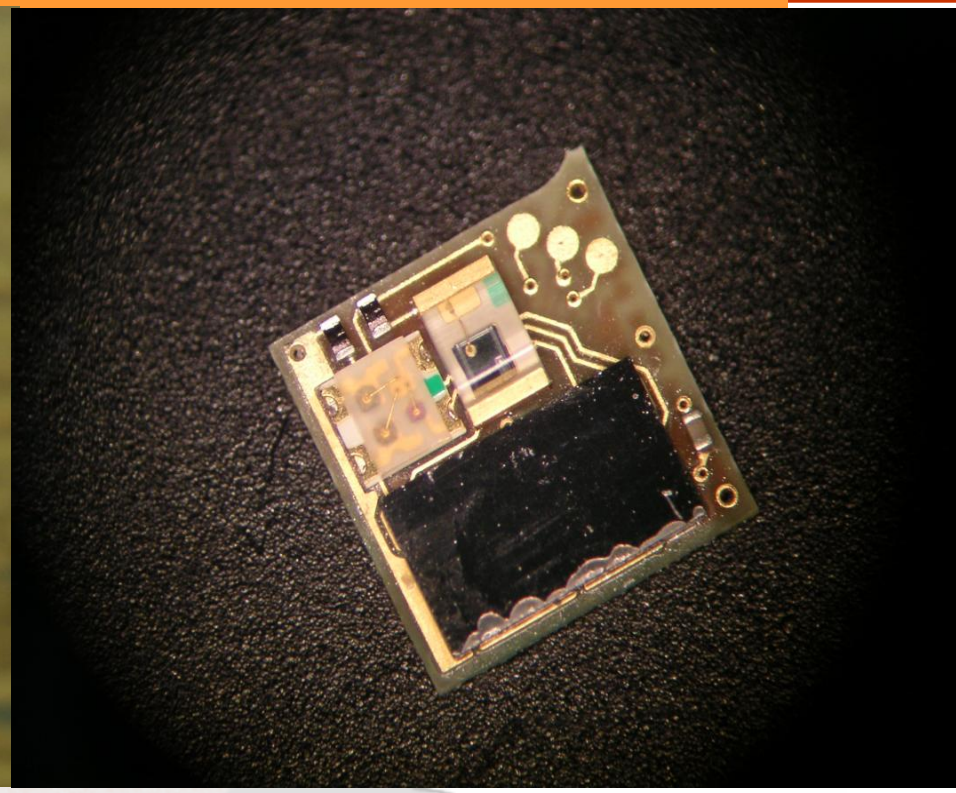




64 node testbed accessible over the internet

5CubeOTS – When size matters





Sensor, Processor, Wireless Networking and Battery in 5X5X5mm

Speckled Computing

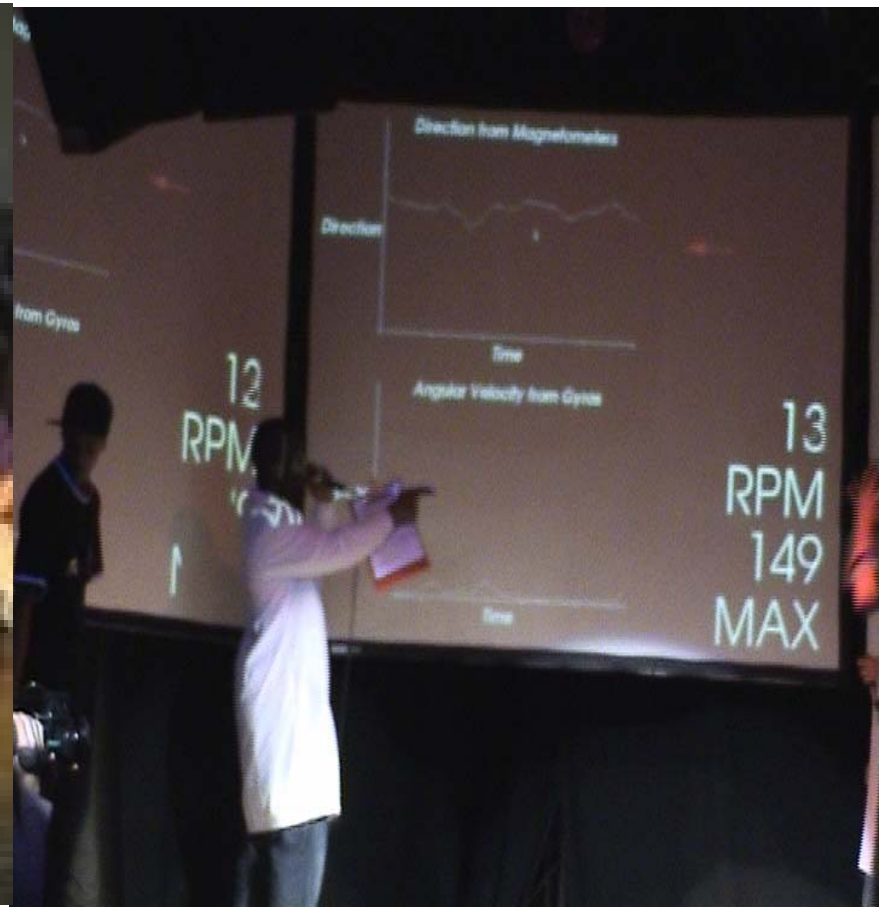
- New models of unencumbered interaction with the digital world, in which the physical world is the primary site of interaction
- Computation and Collaboration at the edges to extract information locally and effect actuation
- Specknet on the person, say a dancer
  - Sensory data such as RPM during rotation (sensory data))
  - Track the movement of the limbs (sensing, collaboration)
  - A robot mimics the actions of the dancer (sensing, collaboration and actuation)
- This information can be accessed and manipulated remotely over the internet

Specknet – the last millimeter of the Internet

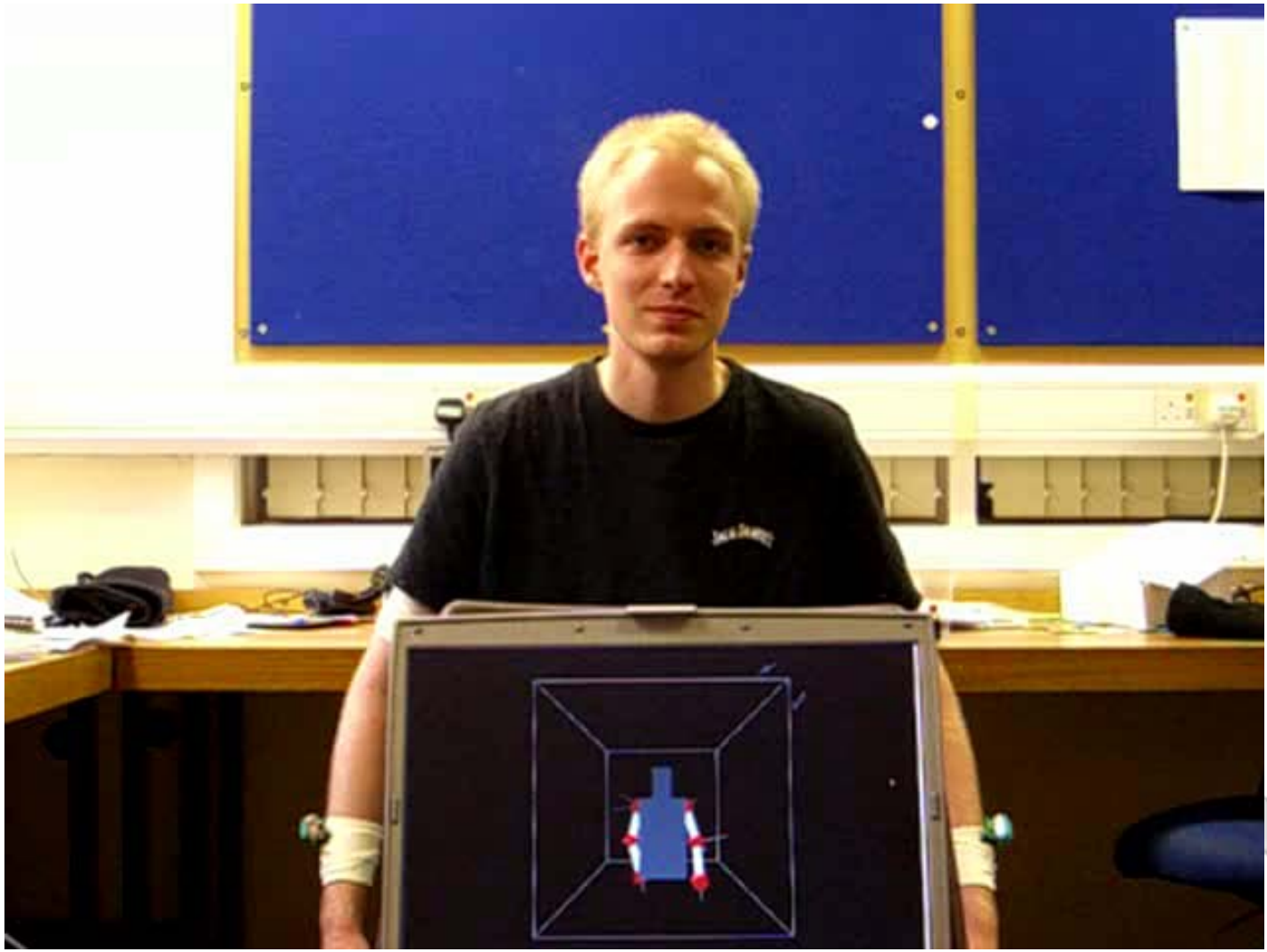
Real-time Monitoring of Breakdancers using Specks

edinburgh international science festival EDINBURGH

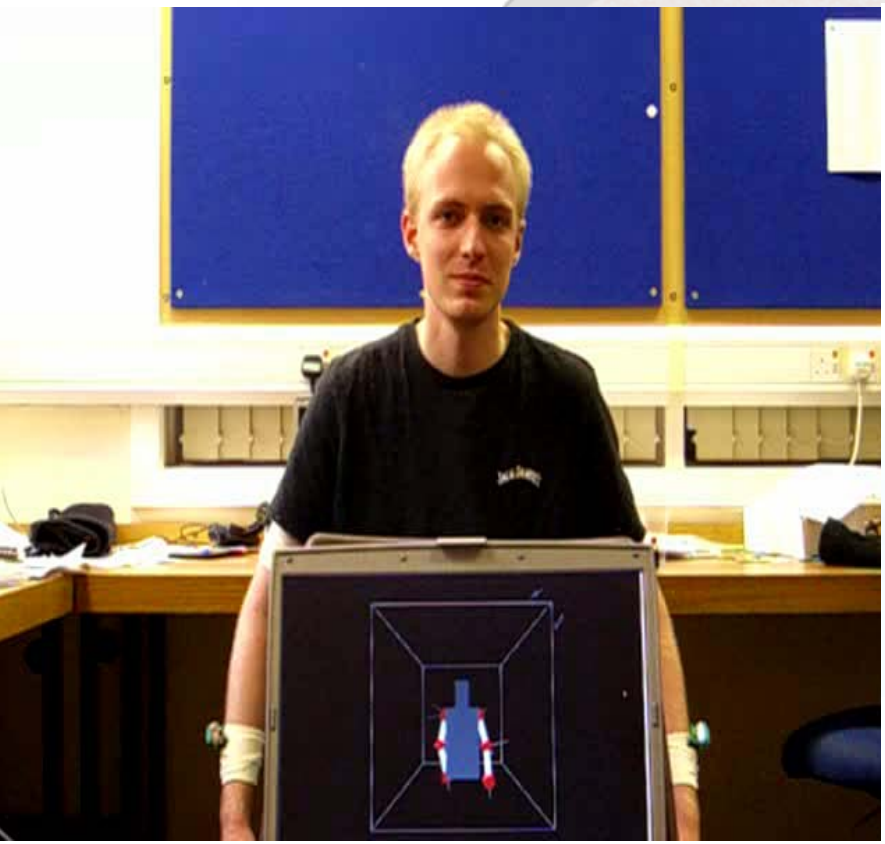
April 2006



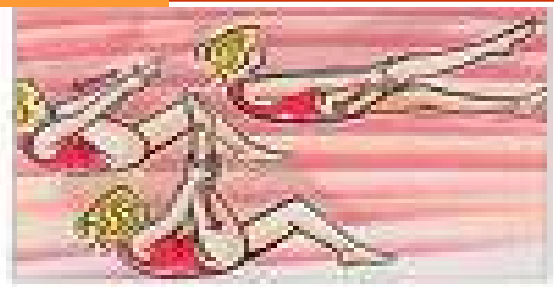
Real-time motion tracking using Specknets

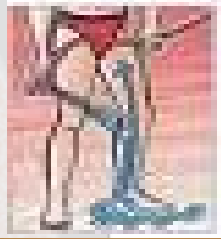


Effect a robot wirelessly to mimic the movements of the human



Orient2 Specknet – Application

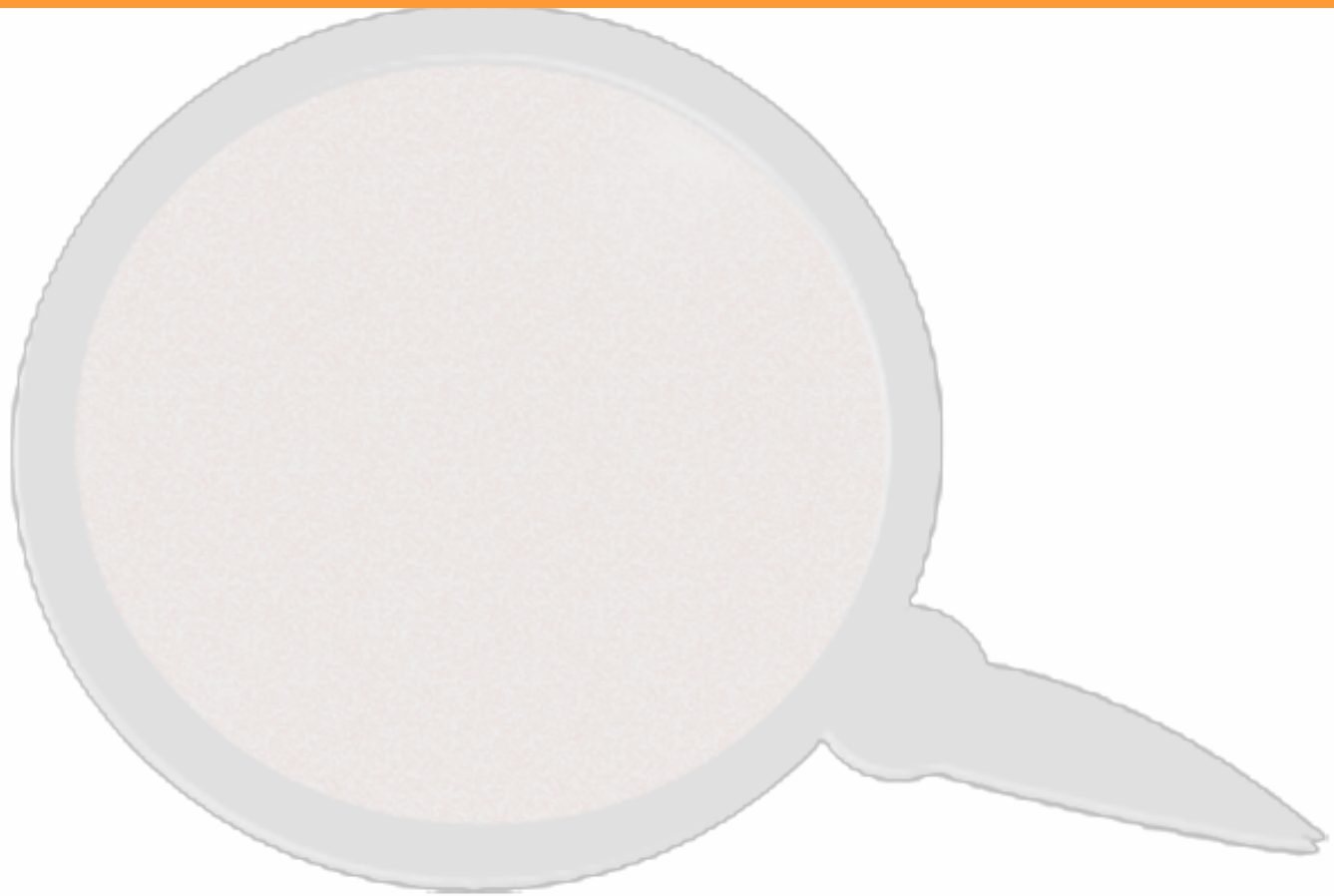




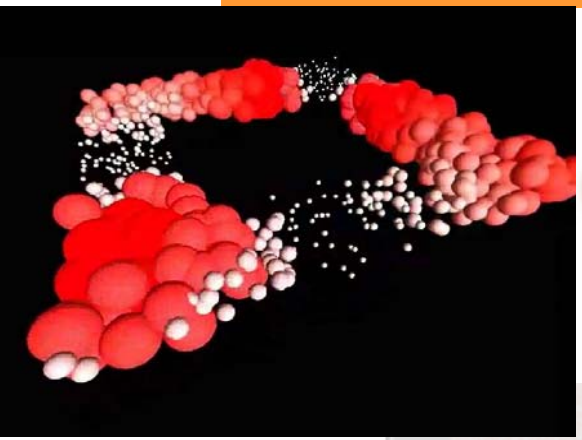
Music from Motion

- Orient Speck consists of 3-axis Accelerometer, 3-axis Gyro, 3-axis Magnetometer, and 5 bend sensors, coupled with processor and wireless networking
- The hand motion determines the fundamental frequency of the sound with finer movements of the fingers determining the harmonics
- A musical composition is created in real-time using physical gestures
- Sensor data is fed to a neural network which is trained for physical gestures

Motion made Audible - Video



Mass Interaction System



Simulation of signal propagation in SpeckSim

CrowdisPlay

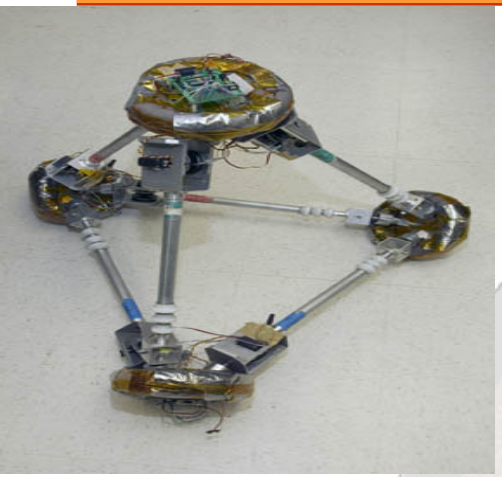
Crowd Rendering: “People as Pixels”

- Place pixels in the real world on people as speck badges with LED
- Speck “pixels” can send information to each other on their relative position, crowd actions and rendering information.
- New form of display which is entirely distributed with no fixed physical position but ever-changing following crowd movement

CONVIVIO

Summer School Atelier in Speckled Computing, August 2006

Mass Interaction System - Robot Crowd



- NASA's shape-shifting robot "TETwalker"
- Eventually miniaturised to form "Autonomous Nanotechnology Swarms (ANTS)"
- Alter their shape to move around large rocks, or create useful structures such as communications antenna and solar sails
- Smart wings in aircrafts

Challenges

- Unreliability
  - Specks manufactured in large quantities – prohibits full functional testing
  - Communications can be intermittent – out-of-radio range, or occlusion for point-to-point (LED or laser) communications mechanism
  - Attrition of specks operating in a hostile environment

- Half-lifetime of specknets – maintain essential QoS, while others degrade gracefully

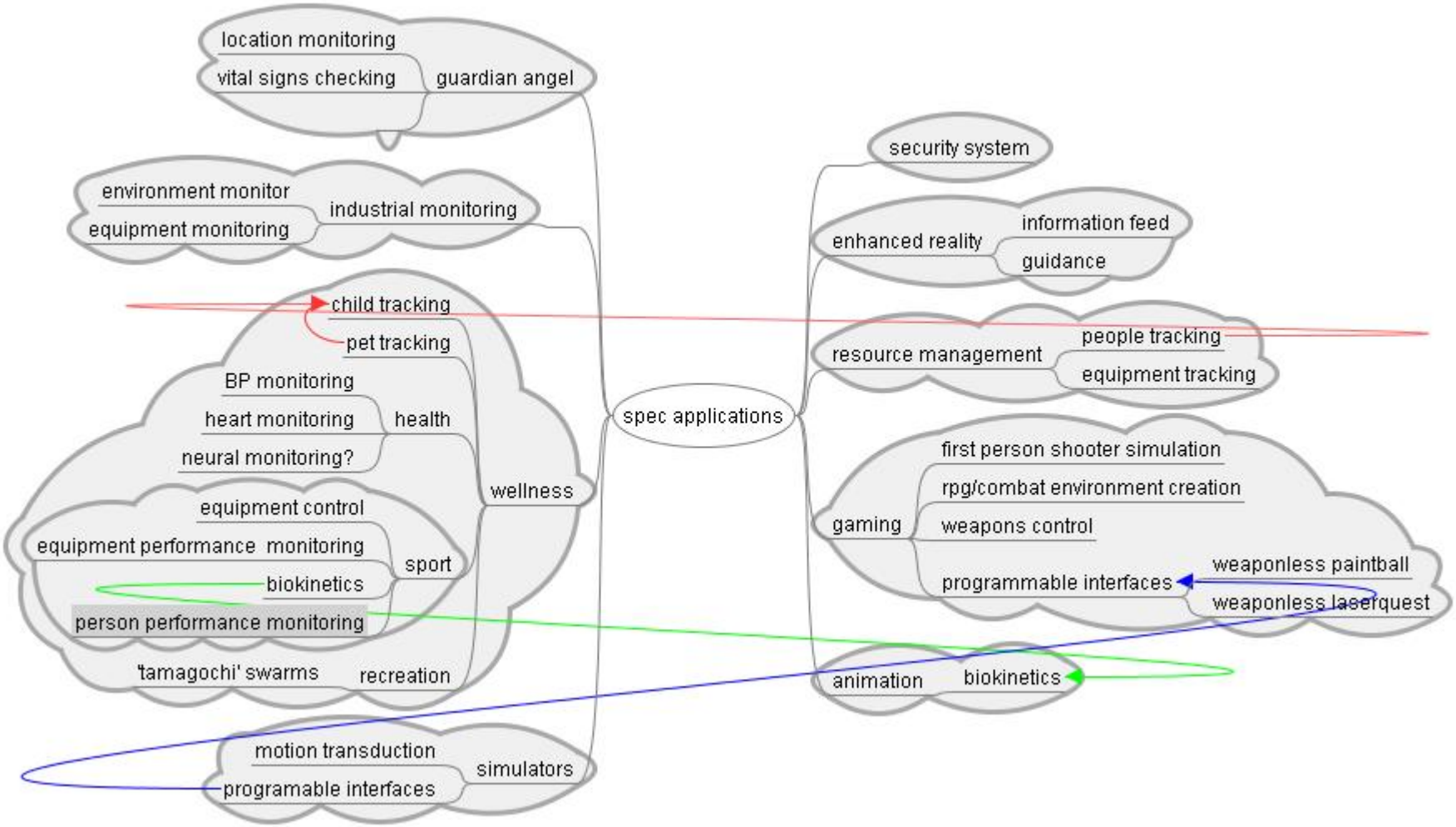
"Specks may come and specks may go, but the specknet should go on for ever"

Restrictions ……

- Resource constraints in each node
  - Space
  - Power
  - Processing speed
- Mobile, ad-hoc, wireless network
  - Protocol issues
- Event-driven, Real-time response

- Decentralised, Leaderless distributed algorithms
  - Zone formation with specified number of nodes in each zone
  - Localisation – the logical location of nodes in a mobile ad-hoc network
  - Tracking and control

Applications Road Map



Interaction System Design

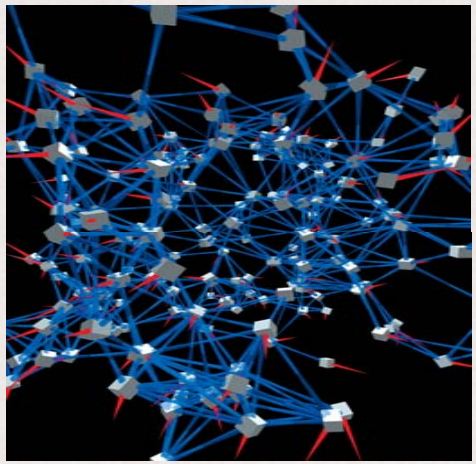
Dynamics of Interaction b/w System & User

Description of Behaviour over Time

Choreograph Behaviour

Visualise Form

Particular Affordances



Program and Understand the dynamics

Empower User To Customise Behaviour

Aesthetics of Use

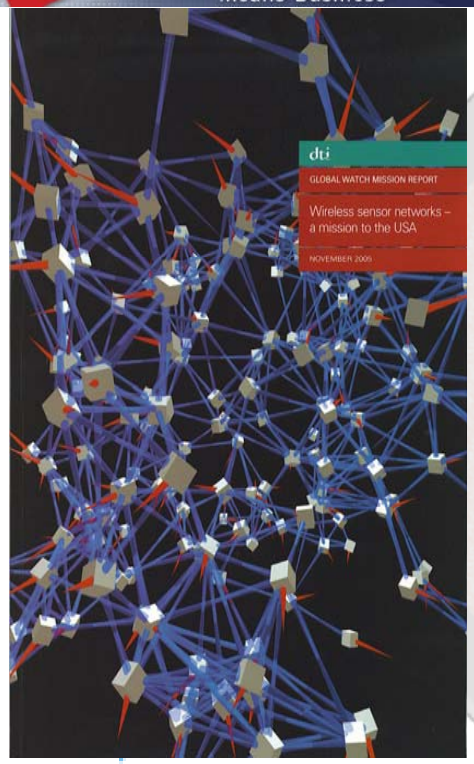
Tangible

Malleable

Create the Overall Interactive System

Montage of highlights in the last 12 months

ZDNet UK Where Technology Means Business



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