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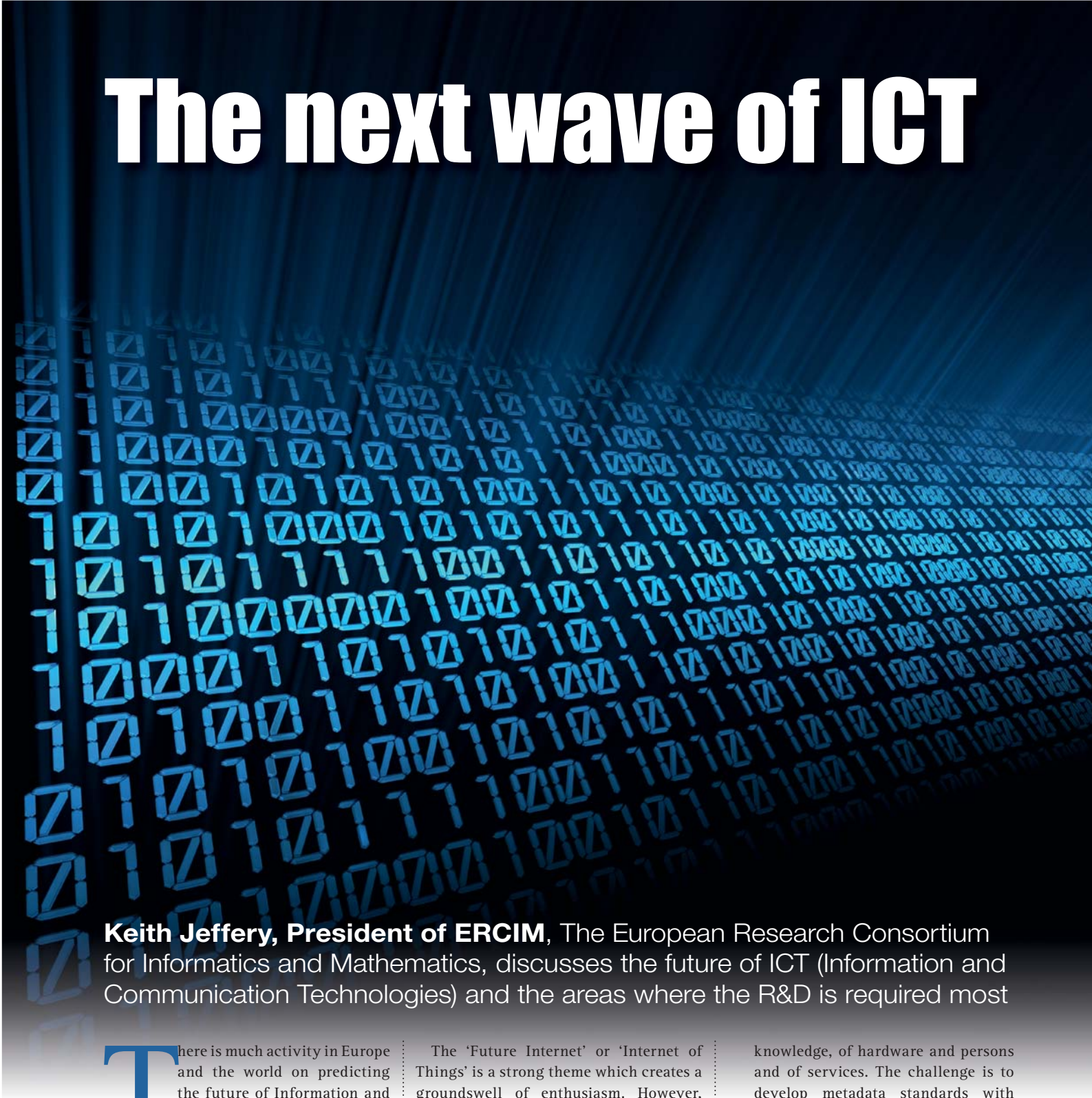
The next wave of ICT



Keith Jeffery, President of ERCIM, The European Research Consortium for Informatics and Mathematics, discusses the future of ICT (Information and Communication Technologies) and the areas where the R&D is required most

There is much activity in Europe and the world on predicting the future of Information and CommunicationsTechnologies. There are roadmapping exercises for R&D in various domains to meet that predicted future. The European Commission has set up expert groups and/or projects covering GRIDs, CLOUDs, Service-Oriented Architectures, quantum and bio-computing, new materials, human-computer interaction and cognitive technology among others. There is much discussion of Web2.0 and beyond.

The 'Future Internet' or 'Internet of Things' is a strong theme which creates a groundswell of enthusiasm. However, this exciting idea poses interesting challenges. Indeed, long-held computer science principles may well have to be jettisoned, in particular in the database technology. Very large numbers of nodes handle volumes that are vast, the speed is fast and the data/information space is global – indeed with space data – universal. The major challenges are:

1. Metadata: is necessary for the description of data, information and knowledge, of hardware and persons and of services. The challenge is to develop metadata standards with formal syntax to ensure machine-readability and declared semantics so that machine-understanding is supported.

2. Management of state: is the core of information processing as the systems represent the state of the world of interest. Elaborate software is used to ensure database integrity and to preserve state; the well-known ACID (Atomicity, Consistency, Isolation,

Durability) transactions and subsequent rollback/recovery or compensation in case of error. However, these mechanisms barely work across 10-100 nodes yet the Internet of Things has millions of nodes across multiple spatial and temporal zones (including out into space) and the existing technologies just do not scale.

3. Data representativity: for too long we have represented the real world as hierarchies internally in the computer system. The real world is a fully-connected graph – a non-hierarchic example familiar to all is one child with two parents. Increasingly the systems will have to handle multiple languages (hopefully all represented through Unicode). Further, the temporal duration of the validity of a data value (probably as the duration of a relationship between data values) will need to be recorded. Much data and information is not absolutely true or false; we need to represent incomplete and uncertain data. We need to represent data such that it can be interoperated which implies canonical representation including all metadata necessary for machine-understanding.

4. Data quality, veracity and permanency: as we rely increasingly that the data in the system represents the world of interest we need measures of veracity or trust in the data. This implies not only the temporal validity but also provenance information and finally curation so that older data may be available (media migration) and utilised correctly in context.

5. Trust, security and privacy: increasingly systems have to trust each other as they interoperate in an e-Business or e-Science context. We need better systems to identify, authenticate and authorise users or systems. Policies need to be declared formally for machine-processing, whether handling access security to ensure confidentiality, privacy or business continuity or trust between organisations in a business transaction.

6. Management of service levels and quality of service: with increasing interoperation and outsourcing, it is necessary to manage end-to-end service level agreements and quality of service. Again, this requires that policies are declared, enforced and monitored through restrictive metadata. Inter-system negotiation will become commonplace; we need to ensure the systems act as we would wish.

7. Systems design, development, maintenance and decommissioning: what is needed in the new world of self-describing and self-managing services is that systems design and development is based on strong separation of processes (including agents) and data, information and knowledge assuming self-composition, self-managing and adjusting, self-maintaining properties and mobile code properties.

All of these are fascinating and difficult R&D challenges. The second challenges conventional database to the core. The third demands a different approach to data modeling. The seventh precludes object-orientation. There is indeed exciting R&D to be done. ★

Professor Keith G Jeffery
President of ERCIM

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