Bringing the cloud closer to users

While maintaining strong data consistency is relatively simple in a centralised cloud, this approach no longer meets the needs of modern online services, which handle huge numbers of concurrent updates. **Dr Marc Shapiro**, Leader of the SyncFree project, tells us about their work in exploring new approaches to maintaining data consistency

Social networks, advertising platforms and multi-player games are familiar features of today's technology landscape. Maintaining the consistency of data in these types of interactive services is an increasingly complex challenge. While historically it was relatively simple to maintain strong consistency in a centralised cloud, increased scalability requirements mean that new approaches are required, an area that the SyncFree project is investigating. "The general idea of the SyncFree project is to investigate how we can decrease latency, and increase availability, so that it scales better," explains Dr Marc Shapiro, the project's coordinator.

The project has its roots in the long-term research of Dr Shapiro and his colleagues, who have worked together on the scalability of cloud and distributed computing. This work attracted the attention of the commercial sector. A number of businesses, including Basho Technologies in the UK, Danish company Trifork and Finnish company Rovio, were looking to deploy large-scale databases for their applications. "They want their data to be always available, accessible and updateable, even when there are poor network conditions or failures. Our research group had principled solutions that were exactly what they were looking for," says Dr Shapiro.

Interactive services

Researchers were in a position to help develop an approach to this practical problem facing industry, namely maintaining the data consistency of interactive services against a backdrop of continued growth in the number of users and the volume of data they generate. Interactive services, such as virtual wallets, social networks and healthcare information networks, have grown rapidly over recent years; maintaining data consistency in these services is a growing challenge, due to issues including geographical spread, network delays, operational costs and hardware failure.

A key question is how data from these interactive services can be updated consistently while also remaining available, in the sense that users are always able to make updates to their database. The SyncFree project's approach is to replicate the data across several distributed data centres, and to develop a method of distributing updates over these copies. "With this approach it is now possible to make multiple updates to the same record at the same time," says Dr Shapiro. "Whereas classically updates need to be coordinated across the whole system, our approach decouples the replicas, and distributes updates to the replicas in an asynchronous manner."

The foundation of this work is Conflict-Free Replicated Data Types (CRDTs), which offer many advantages to programmers, including encapsulation, low latency of updates and full-time availability. These CRDTs also require less computation and network resources, and Dr Shapiro says programmers find them relatively easy to use. "We encapsulate and hide all the complicated programming, of distribution and of concurrency, inside the data type. The basic idea is to support and embrace concurrent updates, and to merge them in a deterministic fashion," he outlines.

CAP theorem

The project plans to maintain open-source libraries of reference CRDT implementations, and develop a highly-scalable CRDT database, which will include familiar abstractions such as sets, maps or sequences, to be used in future scalable distributed applications. A key consideration in the development of such applications is the CAP (consistency, availability and partition tolerance) theorem, which was put forward by Computer Scientist Eric Brewer. "The CAP theorem says you cannot get consistency, availability and partition tolerance at the same time," explains Dr Shapiro. "If you want your data to be strongly consistent

– which is the case with an online bank account for example – then when a network failure occurs (partition) your data will not be available."

By contrast, the project's approach provides partition tolerance, or reliability, together with a weaker form of consistency. Instead of providing strong consistency, so that a user knows their data is the most recent version at the moment that they view it, Dr Shapiro says the SyncFree approach provides what is called eventual consistency. "This is a guarantee that your data will converge as soon as the network is up and running," he outlines. "The data is always available because we allow concurrent updates. We allow a user to read and write, even though the replica cannot connect with other replicas. But that means those replicas might diverge for a short period, so they're not strongly consistent any more."

kind of problem. "CRDTs are a principled solution that is guaranteed to always work," he says.

The evolution of the internet is of course difficult to predict, but Dr Shapiro and his colleagues are looking to improve CRDTs further and adapt them to emerging needs, so that they prove a long-term solution. One area of interest is scaling to much larger numbers of replicas than is currently possible, while Dr Shapiro and his colleagues are also looking at new kinds of applications. "We're looking at applications that have stronger requirements and more complex needs," he says. "We are also looking at making it easier for programmers to access distributed programming with CRDTs, by providing tools so that it's easier to programme and develop these systems."

This research has been driven by a combination of scientific curiosity and the practical needs of industry, which have converged together around a common agenda. The project consortium is relatively small by the standards of EU projects, comprising only eight major partners, and Dr Shapiro plans to pursue further research in this area. "We will continue looking at the problems around scaleability and consistency, and how they could be solved from a principled, algorithmic point of view," he outlines. "We anticipate that future applications will have a kind of transactional approach, where you can update many different pieces of data. We're working on a mechanism that is transactional, scaleable and available."

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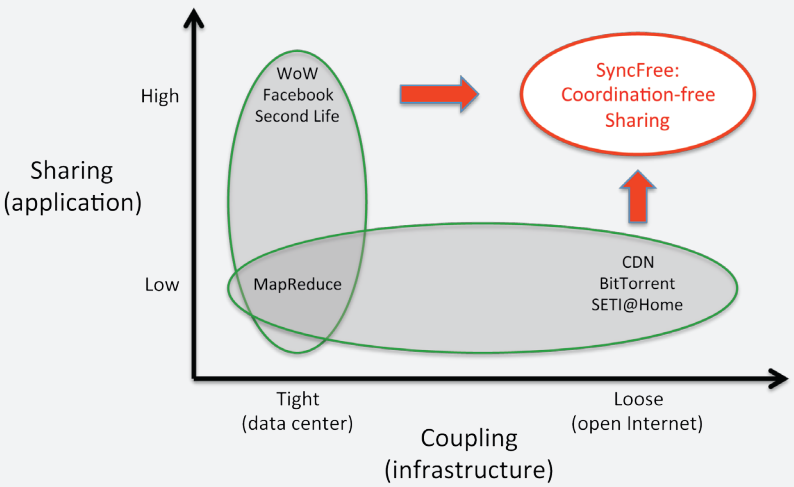
This level of consistency might not be sufficient for online banking, but it is less of an issue in other large-scale online services. The project consortium includes Danish company Trifork, who run an application through which all Danish medication records can be accessed. "Every hospital in Denmark has its own server for this network. Patients can go to different hospitals, and those hospitals share their information. This means that, in an emergency, any doctor from any hospital can access and update the record of any patient," explains Dr Shapiro. The data needs to be available and distributed across different locations; Dr Shapiro says CRDTs offer an effective solution to this



At a glance

Full Project Title
Large-scale computation without synchronisation (SyncFree)

Project Objectives
Large-scale on-line services including social networks and multiplayer games handle huge quantities of frequently changing shared data. Maintaining its consistency is relatively simple in a centralised cloud, but no longer possible due to increased scalability requirements. Instead, data must replicated across several distributed data centres, requiring new principled approaches to consistency that will be explored by the SyncFree project.

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Project Partners
Inria (FR) • Basho Technologies (GB) • Trifork A/S (DK) • Rovio Entertainment (FI) • Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa (PT) • Université Catholique de Louvain (BE) • Koç Üniversitesi (TR) • Technische Universität Kaiserslautern (DE)

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Marc Shapiro is a Senior Researcher at Inria. His research topics cover different aspects of large-scale parallel and distributed computing systems. After his PhD at LAAS (Toulouse), Marc Shapiro did his research at MIT (Cambridge, USA), CMIRH (Paris, France), Inria (Rocquencourt, France), Cornell University (Ithaca, USA), at Sun Microsystems (Chelmsford, USA), and Microsoft Research (Cambridge, UK). He is currently a senior researcher for Inria in the Regal group (Inria-LIP6).