1 Publishable Summary

The objective of the RETHINK big Project has been to bring together the key European hardware, networking, and system architects with the key producers and consumers of Big Data to identify the industry coordination points that will maximize European competitiveness in the processing and analysis of Big Data over the next 10 years. Specifically, RETHINK big delivers a strategic roadmap for how technology advancements in hardware and networking can be exploited for the purpose of data analytics while also taking into consideration advancements in applications, algorithms and systems.

In this project, we did not carry out actual research on Hardware optimizations for Big Data, but rather surveyed the landscape of opportunities in order to propose a strategic roadmap from that landscape. The outcome of the project is a series of detailed (mentioning specific technologies), realistic (considering our 10-year timeline), verifiable (including target metrics) and coordinated technology development recommendations that would be in the best interest of European Big Data companies to undertake in concert as a matter of competitive advantage.

Practically speaking, the roadmap was produced via 89 in-depth interviews with key stakeholders from more than 70 distinct European companies in addition to several meetings with a broad spectrum of industry stakeholders. In order to determine whom to interview, we evaluated the existing competencies across European Big Data application domains and technology providers in Europe and then identified the key European stakeholders, or the established and up-and-coming institutions that possess or are developing the technologies, processes or services that map to these competencies. From these stakeholder institutions, we selected business experts as potential interviewees and asked them to chart the technological advancements, their respective challenges and the potential business opportunities that they present. Generally speaking, we worked to identify experts that not only shared an interest in defining a credible roadmap, but also held the decision-making power within their respective institutions (and collectively) to implement that roadmap.

We conducted 61 Initial Interviews to better understand “the facts on the ground,” meaning the current trends, problems and needs of companies. These interviews were the primary source of content for the Roadmap (D5.3). We then went back to some of the companies that had provided feedback in the Initial Interviews and also reached out to new companies to perform Validation Interviews. We conducted 28 Validation Interviews to request company feedback regarding the specific action plans presented in the Roadmap that the team would later synthesize and integrate into the final version.

At the highest level, this project has identified and evaluated the existing competencies across European Big Data Hardware and Networking technology sectors and application domains and prioritized the complementary interests and the shared opportunities that allow key industrial stakeholder companies to unlock the highest return on their respective investments. The outcome, we hope, is a roadmap that would be irrational not to follow.

1.1 Motivation and goals

In future decades, the ability to process and analyze Big Data will have a greater and greater impact on the European Union's productivity and competitiveness. Big Data describes a massive volume of both structured and unstructured data that is too large to be processed using traditional database and software techniques. It is often seen as the **"oil of the 21th century"**; it is estimated that by the year 2020 there will be 35 zettabytes of data. As Big Data analytics is an important part of the modern ICT society, many European companies rely on it to describe consumer behavior by real-time figures, and to use that information as a guideline for business decisions, effectively reducing risk and increasing profit. Businesses and public institutions are currently being challenged to unlock the potential for the most added-value by making use of Big Data. Offering the right information extracted from Big Data, to the right people, is fast becoming the key to competitive advantage.

- The objective of the RETHINK big Project has been to bring together the key European hardware, networking, and system architects with the key producers and consumers of Big Data to identify the industry coordination points that will maximize European competitiveness in the processing and analysis of Big Data over the next 10 years. Specifically, RETHINK big has focused on delivering a strategic roadmap for how technology advancements in hardware and networking can be exploited for the purpose of data analytics while also taking into consideration advancements in applications, algorithms and systems. The resulting report will be used as a direct reference for technology innovation in Europe.
- In a multi-phased approach, the project has identified critical stakeholders in Europe in the area of hardware and networking support for Big Data, engaged top stakeholder technical experts with access to decision makers, conducted in-depth interviews with these key stakeholders and synthesized the findings into a strategic roadmap defined as a series of detailed, realistic, verifiable and coordinated technology development undertakings that would be in the best interest of EU Big Data companies to undertake in concert as a matter of competitive advantage.

As an indirect outcome, it is hoped that the roadmap will facilitate the coordination between the Big Data ecosystem and public authorities (EU and the Member States) responsible for Big Data research and dissemination programs. It will foster joint initiatives among the main stakeholders in the area of research and innovation programs and RETHINK big members.

Technology roadmapping is a critical activity for a global economy when a near-future technology investment decision is not entirely straightforward, meaning that it is not clear which alternative to pursue and how quickly the technology is needed / will be available or when there is a need to coordinate the development of multiple related technologies. Each of these ideas is relevant in the case of Big Data. The RETHINK big Roadmap must define *which* technical capabilities the European ICT industry needs to develop in order to stay on top of Moore's Law and other trends, as well as defining *when* each of these capacities will be needed.

For this reason, the RETHINK big Project will only be deemed successful having achieved the following outcomes:

- A roadmap that is detailed (mentioning specific technologies), realistic (considering our 10-year timeline), verifiable (including target metrics);
- A roadmap that includes coordinated technology development recommendations that would be in the best interest of European Big Data companies to undertake in concert as a matter of competitive advantage;
- A roadmap that takes into consideration the known Hardware and Networking challenges of performance and scalability, bandwidth and latency limitations, energy efficiency, reliability, and security;
- A roadmap that takes into consideration the known Big Data-related challenges of variety, velocity, volume and veracity;
- A roadmap that accounts for other key enabling technologies from non-Big Data industry and research that might bring disruptive solutions into Big Data;
- A roadmap that facilitates the creation of new international standards, as required;
- A Big Data Technology Ecosystem that includes the key European hardware, networking, and system architects, the key European producers and consumers of Big Data that cooperates with key European existing initiatives in the area of Big Data, HPC, and ICT in Europe, such as the NESSI, the European Data Forum, The European Technology Platform for High Performance Computing and the like…

It is only through this successful roadmap that we can achieve a world-class, globally competitive, European Big Data Technology value chain that provides the key industry decision makers with a mutually beneficial strategy for the long term development for Big Data in Europe.

1.2 Technical work performed and main results

Beginning with the first half of the second year of the RETHINK big Project, the RETHINK big Project Team took a step back from the work completed thus far in order to re-evaluate whether or not we were headed toward a successful roadmap. The P1 Review Report comments brought this definition of success much more sharply into focus, and it was evident that the team needed to turn our efforts to a one-on-one conversation with the key Stakeholders from Industry. We defined a clear methodology for targeting specific Stakeholders and engaged all Project Team members in a formal interview process with clear timelines and targets.

From a Management (WP1) perspective, the RETHINK big Coordinator (BSC) Management Team worked closely with WP5 to plan the Company Interview process for both the Initial and Validation Interviews. This included defining clear objectives for the process, revamping the interview questions, contacting companies and tracking status and results. The Management Team also organized and facilitated several face-to-face meetings, beginning with a project re-planning and SWOT Meeting held on 18 March 2015 in London, a meeting to discuss the P1 Review outcome, the interview process and results to date on 24 June 2015 in Paris and a meeting focused on drafting and incorporating feedback into the D5.3 in Barcelona on 23 Oct 2015. All told, we held 21 Working Group Leader / Task Force teleconferences, 18 Editorial Team teleconferences and 16 Core Team (also known as General Assembly) teleconferences and meetings.

Over the course of P2, the Dissemination Team (WP2) led by UPM and with strong support from BSC focused on improving the overall dissemination strategy of the project with the aim of starting conversations with key stakeholders in Big Data-related business communities, and in particular, with technology providers. We updated the website with various types of content resulting in an upsurge in web sessions. We also appointed technical content coordinators to ensure relevant content was posted through the project's social media channels. Unfortunately, concerns about the maturity of the project in the latter half of P2 led to the cancelation of the Final Conference (as explained in the D2.6) as well as the final dissemination video (D2.7). Despite these drawbacks, we were still able to publish another edition of the newsletter to update the community on project progress as well as produce a video to showcase the first Working Group meeting in Madrid.

The work of WP3 Applications Challenges, WP4 Key Enabling Technologies and WP5 Strategy and Roadmapping focused on getting the best possible information from Industry via a series of interviews. Instead of holding more workshops, we turned our concerted focus to the following: Asking the right questions to the right people and paying close attention to their answers. To some extent, this meant scrapping some of the results we had to date in hopes of gaining real insights from industry and performing our own research into trends and publically available company roadmaps. Out of the target of 125 total interviews for the project, we were able to complete 89 with 74 unique companies / organizations. Out of these 89 interviews, 61 were conducted as Initial Interviews and 28 were conducted as Validation Interviews. While the results of these interviews did not make it into the revised D5.2 Roadmap Recommendations document, they are the basis for the final version of the Roadmap (D5.3) as well as for the combined D3.3 / D4.3 and the D3.4 / D4.4.

1.3 Response to the P1 Review

The P1 Review Report includes recommendations concerning P1, the period under review, as well as for future work. For simplicity, we include a list of the top recommendations here, and each has been assigned a reference number (P1R1 = Period 1 Recommendation 1). Each recommendation has been addressed in this document and can be found via searching the reference number in this document.

P1R1. (Addressed in D5.3, D3.4/D4.4, in Section 3.4) In the part B of the section 1 "Overall recommendations" the reviewers considered that there was a clear need for quantitative requirements tied to business strategy for benchmarking the success of the project.

P1R2. (Addressed in Sections 2.1.1 and 2.2) In the same section, the reviewers stated that the input of marketing experts was missing to produce a clear and valuable message. Business people had to be approached. The consortium should move out since many key companies and relevant stakeholders were missing. An open forum to exchange ideas with people outside the project was strongly recommended.

P1R3. (Addressed in Sections 2.1.2 and 2.2) Addressing the needs of the European automotive industry in terms of big data is a unique chance for the project. With the wider penetration of digital technology in cars and with the growing number of sensors used Europe has the chance to be the one and only market leader in this domain.

P1R4. (Addressed in D5.3) Including additional information about the market, the return of Investment RoI is required. Being more specific on the key strengths of Europe is a key.

P1R5. (Addressed in D5.3) Adding more context from the point of view of European politics and advising on what needs to be done will greatly improve the impact of the project.

P1R6. (Addressed in D5.3, D3.4/D4.4 and Section 2.2) A section on end-user products / applications is missing in the roadmap proposal to alleviate the lack of hindsight regarding the final consumers/customers/market.

P1R7. (Addressed in Section 2.3.2) The project web site has to become more alive and the LinkedIn and Twitter media should be used more proactively to motivate discussions on relevant topics rather than just promoting the project as it was in year. The newsletter and the news on the website have to be issued more frequently.

P1R8 (Addressed in D5.3 and Section and 2.2) ***Feedback on the D5.2****: Most of the facts are provided "AS IS"/ raw data, so the reader must look for the interesting part by, himself [or herself] and filter everything. Along the way, the message became fuzzy and the market view / competitor view fade away. The report has to be improved by focusing the message, summarizing several sections, and giving a proper conclusion on which technologies are the most important for Europe.*

2 P1 Objectives, progress and achievements during the period

2.1 WP3 Application Challenges, WP4 Enabling Technologies and WP5 Roadmapping

2.1.1 Identifying fundamental yet critical issues in the project:

In the last few months of Period 1 and leading up to the P1 Review, the RETHINK big Team identified the following critical issues that would need to be addressed as soon as possible in the new period (P2) in order to produce a quality roadmap: the first issue was that *we weren't asking the right questions*, the second was that *we weren't speaking to the right people / companies*, and finally, *we weren't listening closely enough to their answers*.

ISSUE (1) Not asking the right questions:
In P1, we collected information about Big Data problems from industry via a workshop held in Madrid (the First Working Group Meeting) and also via a detailed technical survey. Through these two methods, we were able to identify a comprehensive list of largely industry-related Big Data problems; however, we did not have enough information from the individual companies to understand how each respective problem generated a specific business need nor did we understand the potential business benefit that could be achieved by solving each problem. The survey and workshop failed to take into consideration the respective business models of each of the industry participants, and the team did not have adequate time to perform the required follow-up.

ISSUE (2) Not asking the right people / companies: