Economic Background of Car-to-Car Communication

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The Car-to-Car Communication technology enables vehicles to autonomously exchange data among each other. The main aim is to improve road safety and traffic flow. Unfortunately, the Car-to-Car Communication technology bears direct network effects, i.e. to be able to profit from it, first a certain market penetration is required. Therefore, the mechanisms generally foreseen by car manufacturers to introduce similar functionalities into the market cannot be deployed. This includes that no car manufacturer can gain a competitive edge by pursuing the market by himself.

On the contrary, this paper shows that a cooperation among car manufacturers and even other parties such as government agencies is required to successfully introduce the technology. Furthermore a mixed approach, of implementing parts of the functionality in series while offering others as options, is presented. It is shown that when perceiving the C2CC technology as a platform for a variety of applications, different user groups, of which some are looking for specific solution to their problems today, can be satisfied.

1 Introduction

The intention of Car-to-Car Communication (**C2CC**) is to enable vehicles to exchange data autonomously among each other via a standardized radio interface without needing to rely on the existence of any infrastructure. This allows e.g. to extend the sensor data base of one vehicle by the data base of another. Like other driver assistance systems this aims at warning the driver of unexpected road conditions or sudden traffic obstructions the vital seconds earlier needed to avoid the occurrence of an accident [KT-a3.03], thus ensuring more safety on the roads.

In this C2CC excellently complements driver assistance systems based on radar, infrared, ultrasound or video. In contrast to these latter technologies it is desired that C2CC collects data in range of up to one kilometre directly (see also Figure 1) and data generated by the (radar, infrared, video, ultrasound or other) sensors of other vehicles.

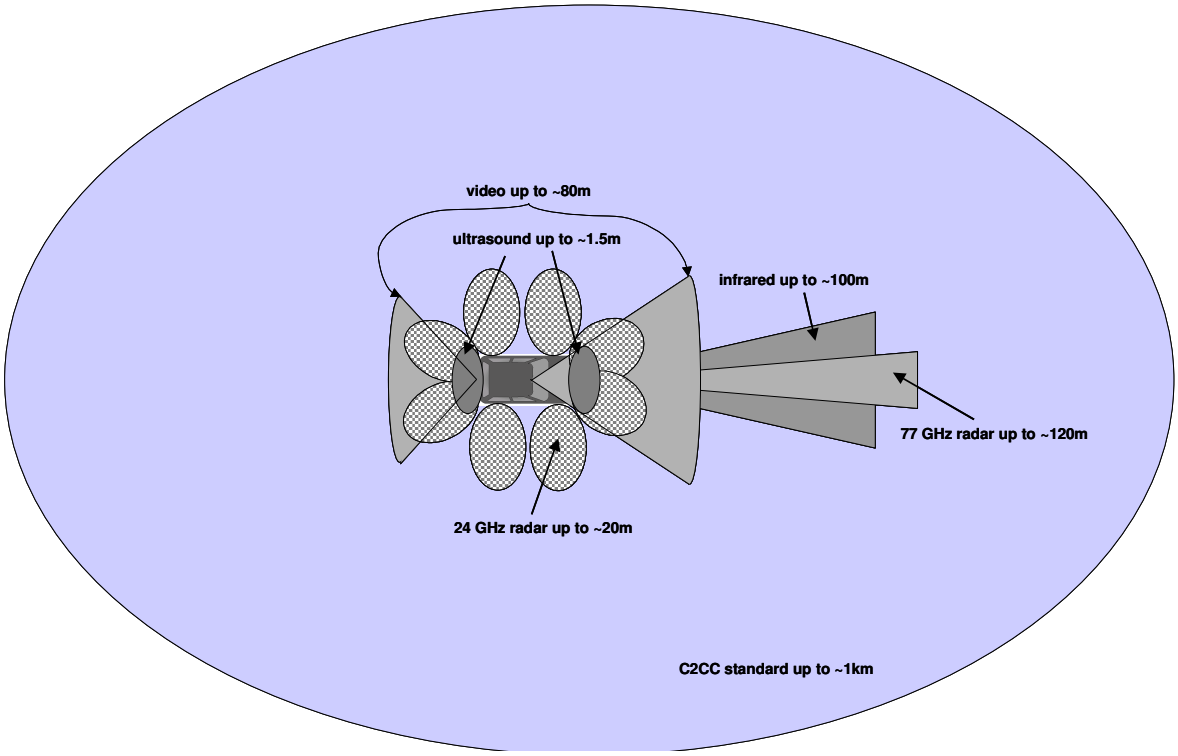

Figure 1: C2CC in relation to other technologies monitoring the vehicle entourage (not in scale)

The inclusion of other vehicles in the C2CC functionality bears at the same time a chance and a risk. The chance is the extended range. The risk is possibly missing reliability, caused when either defective data is received (because the source in another vehicle has generated faulty information or because the data has been manipulated on the air link) or when there are no communication partners (simply because the respective vehicles do not have C2CC units installed).

This shows that technical problems, like security, have to be solved, as well as that there is a substantial economic task to be met. The direct network effects of C2CC mean that the gain of C2CC increases with its market penetration or – like is the case for many C2CC applications– even exists only once a certain penetration is reached. This makes the introduction of such a technology especially difficult.

This paper investigates the economic background of the C2CC technology in detail. It is structured as follows. Section 2 starts with a brief overview on the – economically relevant – technological challenges that C2CC faces. Section 3 introduces a specific view on the economic context of C2CC. Based on this view Section 4, 5, and 6 investigate the gain of the technology for the customers (i.e. the vehicle owners), the car manufacturers and other parties like government agencies and insurance companies. Section 7 draws the final conclusions.

2 Technological Background

C2CC is first of all based on wireless communication. To be sensibly usable for the applications envisioned, the transmission thus has to be robust under adverse propagation conditions, at high vehicle velocities and within a range of one kilometre [WER-a3.04]. Furthermore, the C2CC units have to be able to form a network, in which multihop distribution of packets, addressing and directed routing is possible and in which safety related information is prioritised. In the completed Fleetnet project [FN-e03] quite some of the respective technical issues have been addressed and solutions found. The intention of the ongoing project Network on Wheels (**NOW**) [NOW-e10.03] is to solve the residual problems such that the C2CC technology is mature enough to be introduced into the market.

One of the most critical open issues is the **allocation of frequencies**; at least in Europe. In the US 75 MHz were allocated for intelligent traffic systems in the late 1990s. A similar allocation exists in Europe, though comprising only 10 MHz, which is not sufficient for the objectives of C2CC. Concerted action is required by the key players in the market to influence frequency regulation with the goal to allocate sufficient frequencies resources in Europe.

An equally important issue is – as has already been mentioned – **security**. It is not acceptable for users to receive unreliable or even misleading information from malicious sources. At the same time market success depends heavily on confidentiality to forestall traffic surveillance by legal entities. Basic solutions in the field of ad hoc networks may be available, but their applicability for C2CC has not yet been proven.

The selection of an **IEEE 802.11a** based technology for C2CC in the US makes a related technological choice in Europe likely. Important reasons for choosing an IEEE 802.11a based technology were economic ones. A (yet unconfirmed but not impossible) claim of chip vendors is that the retuning of IEEE 802.11a chips for C2CC can be done for less than 10 cent per chip [Viq-e03]. The economic rollout could thus be quick and easy and the C2CC

devices interoperable with other IEEE 802.11 devices already on the market. The latter is – as will be shown below – not just a nice add-on, but a necessity for the successful market introduction.

Nevertheless, IEEE 802.11a has not yet proven its technical applicability to C2CC. It can be expected that the IEEE 802.11 **MAC protocol** will lead to low performance and that the **radio resource mechanisms** require some tuning. The asynchronous character of the MAC protocol will further lead to conflicts with the use of different services on different frequencies.

3 Economic Background

For consumer technologies there are two mechanisms that lead to a successful market introduction:

Either there is a **visible added value** of the technology for the customer and/or

a **regulative order** that does not leave alternatives requires its use.

A significant improvement of road safety due to C2CC might actually justify the latter. NOW claims that with C2CC the probability of about half of the approx. 450.000 accidents that happened in Germany in 2002 would have been significantly reduced. With a macro economic loss of 34 billion Euros due to traffic accidents in 1998, an actual avoidance of just 10% of these accidents would have resulted in a loss reduction of 3.4 billion Euros [NOW-e10.03]. Furthermore, a the European Communities directive exists according to which the participating countries shall reduce their road fatalities by 50% within the next ten years [EC-e01]. A generally better traffic flow – that is also in reach with C2CC – is also a strong economic force. [INV-e04] presents numbers after which in Germany alone every day 33 million litres of wasted fuel, 13 million hours of delay and an economic loss of 250 million Euros are caused by traffic congestion.

The catch to a regulative introduction is that, to be issued, the effectiveness of the C2CC technology has to be proven first. In case of technologies without network effects (like e.g. safety belts) this might be achieved by crash tests and the limited introduction in the field. But in case of C2CC, a certain penetration in the field is required before the effects can be unambiguously shown. Hence, it cannot be expected that a regulative order on the basis of

expected safety and traffic flow improvements is issued before the penetration is reached. The C2CC market is thus unlikely to be driven by such a force[1].

Owing to the network effects the situation is equally tricky when investigating the added value for the consumer. When a consumer can only take advantage of a technology once a certain market penetration is reached, he or she will not invest in this technology before this is the case, which again means that this penetration will never occur.

The classical approach for the introduction of new consumer technologies, to rely on early adopters to refinance development costs, or – as done in the automotive industries – to introduce a new technology top down, first in upper class vehicles and then generation by generation in lower classed vehicles, is consequently unsuitable for C2CC.

Especially difficult are the large numbers of C2CC units required. In Germany there are about 47 million registered road vehicles [KBA-w04]. The typical safety related C2CC application needs *at least* 10% penetration [FN-e03], i.e. 4.7 million vehicles. About 3.2 million cars and 200.000 trucks were newly registered in 2003. If all of these were equipped with C2CC the 10% would be reached in a reasonable time of under 1 ½ years (see also Figure 2). If just 50% of the vehicles were equipped (which represents in Germany about all VW corporate, BMW, and DaimlerChrysler vehicles or all the middle class and larger vehicles of all manufacturers plus the trucks) the duration would increase to about three years. In comparison, company cars are resold in average after about 2 ½ years [KBA-e99]. The respective owner would thus resell a car with a technology he or she never had the chance of profiting from.

Still, to approach an equipment rate of 50% is seen as a reasonable target. More is (unless a regulative order is involved, which, as has been discussed, is unlikely) not realistic, as not all manufacturers would be in a position to equip all vehicles at once. Only the eleven biggest brands in Germany[2] with 82% market share sell over 120 models. New features are introduced at specific intervals, either with new models or with model updates. This means that even with significant effort more than 50% will be difficult to reach. At the same time, to

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[1] Note though that there might be other applications not requiring a specific penetration that might well be in the scope of government agencies, see also Section 6.1.

[2] Which are for passenger cars (in order of market share): Volkswagen, DaimlerChrysler, Opel, BMW, Audi, Ford, Renault, Peugeot, Toyota, Fiat, Skoda.

aim at less than 50% would risk to delay the introduction of C2CC into trifling; 10% equipment rate has been mentioned as a lower bound. For quite some C2CC applications a larger rate is needed.

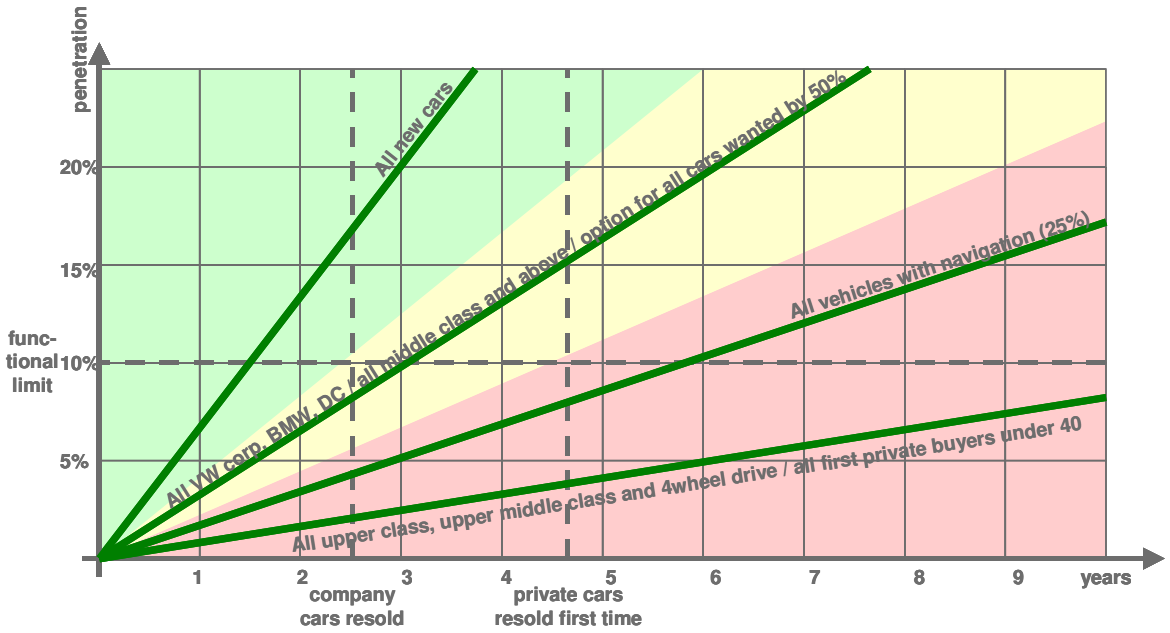

Figure 2: Equipment ratio in relation to time needed until C2CC functional

The general idea is to introduce C2CC with help of Car-to-Fixpoint Communication (**C2FC**) applications, which cover also the areas comfort and infotainment [NOW-e10.03]. The communication with fixpoints has the advantage that the fixpoints can be installed independently from the equipment rate of the vehicles. Discussed fixpoint communication counterparts are traffic infrastructure, enterprises, public hotspots, personal equipment and alike.

Naturally, the annihilation of the networks effects by focusing on C2FC applications is a step forward to introducing the technology. Still, to envision the introduction of C2CC with C2FC optional applications is also naïve. As has been discussed, a 50% equipment rate is required. Just to give an idea on the size of specific user groups: 25% of the customers are in positive prognosis expected to buy the vehicle with navigation systems [ADAC-p4.04], 13% of vehicle buyers are younger than 40, 9% of cars sold are upper middle class or upper class [KBA-w04]. To find an application that is bought by 50% of the customers is – also when looking into the history of automotive features in more detail [CKKW-a5.03] – not obvious.

In consequence, **C2CC can only be introduced as standard equipment** and only if several car manufacturers decide on this. No manufacturer can gain a competitive edge by going alone. The question then of course is, how the serial production would pay off for the manufacturers.

The authors thus propose the following model:

1. Every vehicle is equipped with a basic C2CC unit. This unit can generate and forward C2X messages. It does not need to include the capability to also interpret the messages for the use inside the vehicles it is installed in (and therefore does not need a Human-Machine-Interface (**HMI**)). The motivation for this unit is solely to achieve as quickly as possible a sufficiently large penetration rate, such that in a later phase the C2CC functionality might indeed be profited from inside (other) vehicles (see **5**.). Until then the basic C2CC unit is not marketed.

2. A variety of C2FC applications is offered to the customers (see also Section 4). The sale of these options finance the cost of the respective C2FC application, as well as parts of the basic C2CC units installed in all vehicles.

3. Another share of the costs is refinanced by the car manufacturer himself. As the C2CC functionality is more a platform for numerous applications based on wireless communication than a specific application itself, this functionality can be exploited by the car manufacturer. Possible areas of deployment are customer and vehicle relationship management as well as the use for optimized production processes (see also Section 5).

4. Also government agencies or insurance companies might refinance specific C2X applications. Possibly not directly to the car manufacturer but indirectly via giving bonuses to customers having chosen certain options. This refinancing could be in tax or fee reduction (see also Section 6).

5. Once certain penetration rates are reached, the respective C2CC applications (i.e. the possibility to profit from these C2CC applications inside the vehicles the unit is installed in) are also sold to the customers. Possibly, the functionality might then, for some fee, be activated retrospectively in vehicles having had built in C2CC units before the penetration was reached. Then, though, an HMI has to be installed to begin with.

Note that to increase the penetration rate by aftermarket sales is difficult. C2CC require the availability of sensor data. Without being integrated with the vehicle bus system and HMI the usability of C2CC is very limited. Such an integration is more complicated to realize in the aftermarket. Figure 3 visualizes the concept proposed above.

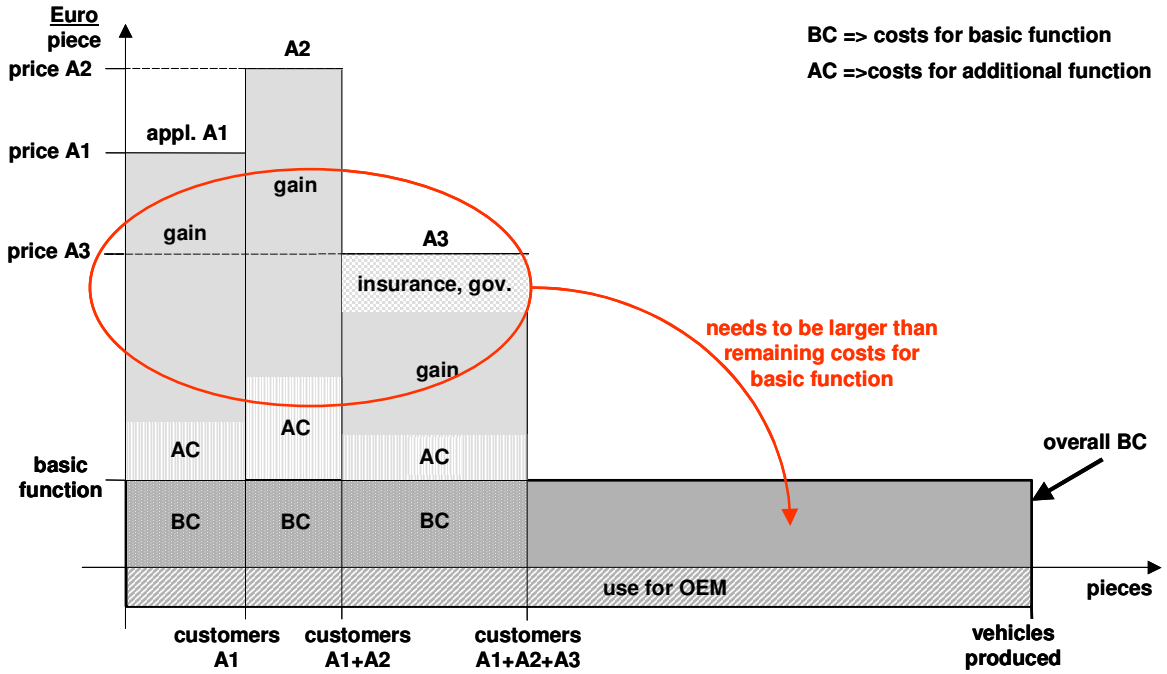

Figure 3: Basic concept of the C2CC business model

4 The Customer

4.1 User Groups

For different user groups different applications are attractive. For this reason a distinction is made between the private user, the business user and the fleet manager:

In Germany the largest share of vehicles (~85%) is owned **privately**. This large percentage though is reflected neither in the number of new vehicles bought every year nor in the kilometres driven. About 43% percent of newly registered vehicles are privately owned (though 98% of all second hand cars are bought by private persons). Privately owned cars are the least used; in average they are driven less than 10.000 kilometres a year [DIW-b03] [KBA-w04]. A significant share of these kilometres is driven in the spare time. The private user is therefore – next to being interested in getting quickly from one place to another – prime candidate for comfort and fun applications. Despite the potentially huge number of

customers, the willingness to pay for services and applications in this group is generally rather low [PO-e4.03]; an experience well made in telematics.

The **business user** is someone who drives the car for professional reasons, but does not make money by driving itself. Business users are generally preferred early adopters, as they are likely to be willing to invest in new technologies. Nevertheless only, if advantages for the work progress are seen that outperform other technical alternatives [PO-e4.03]. Their share in traffic is not negligible. Respective companies own 9.5% of all vehicles, with an over proportional percentage of new vehicles (45%). With approx. 25.000 km per year, each of these cars is driven significantly more than the privately owned ones. Nevertheless, for the envisioned C2X applications, only up to date traffic information is really of interest. For obtaining specific information on the way (email, stock, progress etc.) more comfortable technical alternatives exist which do not require a wireless link into the car.

For the **fleet manager**, the basic functionality of the vehicles itself (driving) is the main source of income. This means that with a comparably small share of vehicles (around 5%) a large share of the traffic is generated (roughly 15%), with each vehicle thus driving a multiple of what a privately owned car covers. In principle, the fleet manager has a high interest in everything that improves the business. He or she will invest according to the anticipated savings and/or improved business opportunities. Four fleet operation businesses with different preferences are considered:

- **Delivery service**: Counting all company owned trucks smaller 3.5t as delivery trucks, 1.42 millions are registered in Germany (of which one 10^{th} was newly registered in 2003). These smaller trucks drive around 34.3 billion kilometers a year. A lot of delivery traffic is found in inner city areas. In [INV-e04] it is claimed that approximately 40% of the urban traffic is in fact transport of human beings and of goods, as privately owned cars are often used only for a small fraction of time. Delivery services are interested in optimizing the number of kilometers driven and the delivers times, as well as gaining transparency on the delivery status.
- **Transport companies** (heavy goods traffic): 371.973 trucks (≥3.5t) and 178.114 semitrailer trucks are registered in Germany with about one tenth of them new. The trucks drive about 28 billion kilometers per year, the semitrailer trucks drive about 12.7 billion kilometers per year [KBA-e1.04] making the vehicles in this

category the in average most heavily used ones. Important economic factors in the heavy goods traffic are delivery times, kilometers driven and petrol consumption. The majority of the heavy good traffic is found outside towns.

- **Car rental**: Car rental companies own about 355.000 vehicles in Germany. A very large percentage of these (~78%, 276.000) is newly registered every year. This means that the turn around time for car rental vehicles is very small and that they are resold quite soon after first release. The car rental companies are naturally not concerned with the driving itself. For them optimizing the rental procedures, i.e. check-in and check-out processes as well as the observance of the contract terms are issues of interest.
- **Taxi services**: Since 1992 an unchanging number of about 53.000 taxi concessions exist in Germany. Exact numbers on the kilometers driven do not exist, though an average of 60.000 km per vehicle are seen as a reasonable estimate. This means that their share in urban traffic is over proportionally larger compared with privately and company owned cars. For taxi service it is of interest to increase the number of customers and/or to decrease the costs. Customer satisfaction, e.g. owing to timely arrivals, might help the former. Costwise the robustness of the cars as well as their petrol consumption are important issues.

4.2 Car-to-Fixpoint Applications

When discussing C2FC applications, and especially their suitability as introductory applications, three criteria are of importance:

- The required coverage, i.e. **distribution** of fixpoint communication counterparts: Variations exist from “any (limited) area imaginable, small” (e.g. personal equipment, company parking lot), “coverage of certain areas” (e.g. one city), “coverage of certain road type” (e.g. all motorways), “nationwide coverage, large” (e.g. SOS request, vehicle location).
- The required **networking** behind the fixpoint communication counterparts: The range goes from “the units do not to be connected to any other source of information, none” (e.g. warning signs at construction sites, personal equipment), to “the units have to be connected locally” (e.g. several fixpoints in a local parking guide, home network and garage), to “the units need to be connected to

the internet" (e.g. at hot spots), to "the unit have to be connected to a specific backbone network behind the internet, extensive" (e.g. diagnostic data collection of a specific OEM).

- The **attractiveness** of the application with respect to the price obtainable. The value varies significantly with the user groups introduced above.

Naturally, those applications are specifically suitable as introductory applications, that require little or no networking, that are applicable in any limited area and that are very attractive to the user.

Figure 3 categorizes a selected number of applications. The applications found in the lower left corner are those especially suited for the early C2FC market (they are discussed in more detail further below). For all other applications significant effort is required with often several business partners involved. This accounts also for the two applications marked as "hype": Car-to-Hotspot (**C2HS**) and MP3 downloads. Nevertheless, the installation of hotspots and the marketing of MP3 music files currently receive a considerable amount of media attention. With their (not unlikely, but not yet known) market success they will move into the lower left corner of the diagram, as then the necessary infrastructure can be accounted for as given. Both applications are thus be included in C2X business concept.

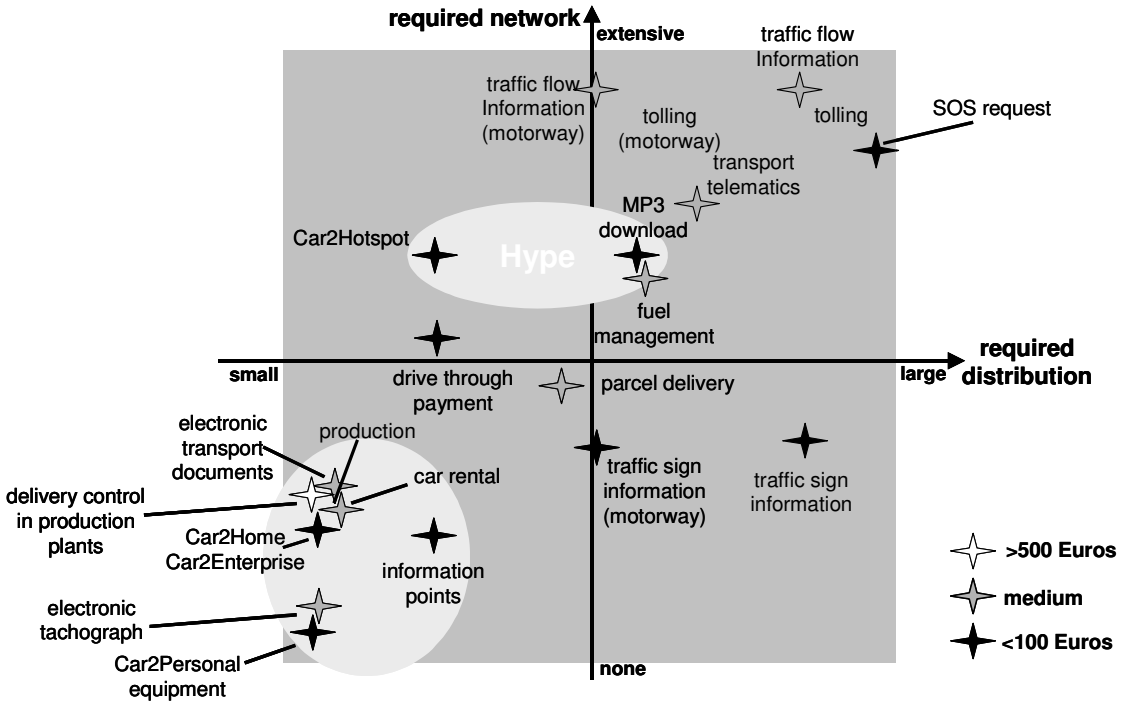

Figure 4: Categorization of C2FC applications

Of the applications found in the lower left corner of Figure 4, three are for transport companies: electronic transport documents, electronic tachograph and delivery control in production plants. All three applications are issues today. Hence, technical solutions exist or are sought after. The introduction of the electronic tachograph is even supported by legislation (see e.g. [EC-e8.03]). This means that the earlier the C2CC communication interface is included in the concepts the better.

Also car rental companies are today looking into the optimisation of their processes. The use of wireless connectivity is already tested e.g. at the car rental return station at the Munich airport. Therefore also their needs bear a potential for introductory scenarios.

Next to the C2HS and MP3 download application, of interest for the private user are Car-to-Personal Equipment (address book/ calendar synchronization, music download into the vehicle form mobile devices etc.), Car-to-Home (comfortable download of route planning information, music program etc from the home PC into the car) and the use of information points. With the latter local information e.g. on parking space or tourist sites can be made available in the vehicle. Decisive for the acceptance of these applications are that they are very cheap to have, easy to use and that they do not cause an information overflow.

Companies can make use of the C2CC functionality on their premises, either by providing specific information or improved organisation (e.g. company parking entrance). Drive through payment is a related application, but not suitable for the introductory scenario. C2FC based drive through payment can, in fact, be installed in isolated set-ups (e.g. petrol stations, drive-through restaurants), but it cannot be expected that anyone will do so before a certain penetration with C2CC units is in the market.

The discussion above shows, there is no *one* C2FC application suitable for the introduction of C2CC. Nevertheless, there is a number of applications from which vehicle customers might like to profit. The C2CC technology should thus be seen as a platform on which numerous applications requiring wireless connectivity to the vehicle can be realized.

4.3 Car-to-Car Applications

As soon as a certain penetration of C2CC units is reached, C2CC applications can be marketed. While the realistic C2FC applications aimed at comfort and fun as well as efficient work processes, the main focus of C2CC applications is on safety and traffic flow.

Traffic flow applications can also be realized based on infrastructure. But this would require extensive networking of many installed fixpoint units. Additionally, the improvement over existing traffic information systems is questionable. The problem is not so much the distribution of the traffic information as their reliable generation. Like the existing traffic systems, the C2FC based system could generate information only where infrastructure is. This changes entirely with C2CC. With C2CC every C2CC enabled vehicle is a source for traffic information, so information can be generated wherever problems and C2CC enabled vehicles are. It can even be expected that there is a certain willingness to pay for reliable traffic information[3]. C2CC traffic information applications are thus of large interest (for the private user, the business user, the delivery truck, transport and taxi company owner) and need to be part of any C2CC marketing concept.

Safety related applications are most important, because, as has been mentioned at the beginning of this paper, C2CC allows to evaluate vital information otherwise not available in the vehicle. Nevertheless, C2CC safety application will be more difficult to sell. Users rather expect that the latest safety features are included in the vehicles, than that they need to pay for them.

With a certain penetration of C2CC units, fleet management applications become feasible that would require too much infrastructure in case of C2FC: transport telematics, fuel management and improved delivery service. C2CC marketing concepts should also include this potential.

5 The Car Manufacturers

The direct business for the car manufacturer is to sell vehicles. In the context of C2CC this would mean that the costs for installing C2CC units in the vehicles are below of what the customer pays for it. As has been mentioned in Section 3 though, C2CC cannot be marketed as a standard option to choose. Owing to the large market penetration required, a basic functionality has to be provided in every car. Additionally, specific C2FC applications should be sold as options to cover some of the expenses for the in series installation of C2CC units. Further of interest is how the car manufacturers can counter finance the installation of the

[3] Provided the user can experience it. This has been the difficult part in existing systems.

C2CC units by profiting from the wireless interface themselves, outside the direct line of business.

In the context of vehicular telematics the use of a such a wireless connection for the car manufacturer has already been investigated. The respective keywords are customer and vehicle relationship management (**CRM** and **VRM**). [STWF-a02] e.g. see a significant potential in properly exploiting the comprehensive technical data obtainable from the vehicles by the wireless link. A brief overview on the profit sources shall be given here.

Main advantages in the context of VRM are:

- The **remote diagnostics capabilities** allow for more efficient new product development and more effective utilization of safety margins. They furthermore help with the choice of suppliers and the prove of reliability. The possibility to remotely fix vehicle failures reduces customer irritation and helps to avoid costly dealer interventions.
- The **warranty and liability management** can be improved, as problems can be noticed earlier and alternative ways to contact the customers exist.
- The car is more reliable, because actual and future problems can be predicted and taken care off better. The vehicle might therefore sell at a **better price**.
- The data base enhanced **repair** allows for optimised scheduling and lower parts inventory. Fewer costly overnight deliveries are required.

The main advantage in the context of CRM are:

- Owing to **detailed customer understanding** and vehicle monitoring, suggestions for upcoming vehicle replacements with specifically tailored models are possible.
- The **customer contact can be occasionalized**. Instead of mass mailings just those with likely interest can be informed about useful equipment, software upgrades and alike.
- Thus enhancing the customer's seamless ownership experience is **brand building**.

Especially in the CRM a high potential for additional profit is seen [STWF-a02]. Nevertheless the respective data is also more difficult to obtain. For the personalized data the consent of the owner is needed for its use. Furthermore, a not insignificant fixpoint

infrastructure would be needed to be able to collect the data, should the C2FC interface be exploited for this purpose. Additionally, the return on the investment concerning CRM and VRM in the context of C2CC units is realized with a delay

Despite the nevertheless undeniable potential in the availability of the data basis, the collection of statistical data is not very suitable to finance the introduction of C2CC. It should be included in the business of the later phase.

Still, the car manufacturer can exploit the C2CC interface upfront. In the production process wireless technologies (even IEEE 802.11a) are in use today and their further deployment to optimise the processes is being investigated. Having the interface integrated directly in the vehicle thus bears significant saving potentials, especially bearing in mind that 100% of the vehicles are equipped.

6 Other Parties

6.1 Government Agencies

It has already been mentioned that government authorities must have an interest in C2CC, because of its potential to significantly reduce the number of accidents as well as to improve the traffic flow (and thus to lower the macro economic costs). It has also been explained though that knowing the potential theoretically is not enough to ensure the introduction of C2CC by legislative means. Nevertheless, apart from road safety and traffic flow, there are other areas in which government agencies might profit from the C2CC interface:

- The optimisation of **tolling** is an urgent case all over Europe. In Germany automated truck tolling is still waiting to function, in countries like France or Italy, manned toll both are being replaced by radio wave triggered ones. Furthermore, the European Commission is asking for proposals on compatible, cross border, single contract, wireless solutions for tolling [EC-e6.04]. Getting the vehicular IEEE 802.11 (C2CC) or one of the IEEE 802.11a/b/g technologies into this (or any other tolling) concept, would mean a very good opportunity to get C2CC into the market. Additionally, the tolling infrastructure could be employed as gateways for other C2FC applications, allowing for numerous more applications than have been discussed here.

- When considering C2CC based **law enforcement** it has to be kept in mind that allowing to track speeding and alike with help of C2CC would jeopardize completely the acceptance of C2CC (even though its use might be desired by the authorities [EC-e6.04]). Nevertheless, for some applications, where a wireless link is needed anyway (like observing the electronic tachographs, see also Section 4.2), it makes sense to employ the C2CC platform for this purpose. Theft tracking is another application frequently discussed for wireless applications. Next to the large C2FC coverage such an application would need[4], its efficiency is not obvious, as shielding or disconnecting the antenna would be sufficient to render the application useless.

- Also government entities are interested in collecting **statistical data** for their purposes. Nevertheless the same applies as for the car manufacturer, a not insignificant infrastructure is required. The only difference is that government entities have it in their hands to decide on the reuse of e.g. tolling infrastructure.

6.2 Insurance Companies

When looking at the statistics it can be seen that depending on where and how much you drive the probability to be involved in an accident varies considerably: In average you have to drive 270.000 kilometres to be involved in an accident and 1.24 million kilometres to be injured. If you drive on motorways only, the probability to be injured decreases by about factor four. There you have to drive almost five million kilometres before you are harmed (all numbers for Germany 2000 [SBD-w04]). Based on similar arithmetic some insurance companies adjust their fees according to the use of the car. A large insurance company in the UK pilots a telematics aided “pay as you drive” insurance with 5000 volunteer motorists. The telematics unit reports (with help of GSM and GPS) time, location and quantity of driving from which then the premium is calculated [IBMf-p3.03].

For such purposes also the C2FC functionality could be deployed. Unfortunately, such applications would nevertheless require the availability of more infrastructure than can easily be expected to be available in the starting phase.

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[4] For applications that require close to complete coverage like theft tracking or SOS request, relying on a GSM based mobile phone network.

7 Conclusion

Car-to-Car Communication (**C2CC**) is a technology envisioned to improve road safety and traffic flow. In contrast to other driver assistance systems, C2CC is a technology with large network effects. Network effects mean that the gain obtained with C2CC increases with its market penetration. Below a certain penetration rate the use of C2CC is very limited.

The penetration needed is quite large: To reach it in a sensible amount of time, 50% of *all* new cars have to be equipped. This has several consequences for the market introduction. a) C2CC cannot be introduced in the top down approach typically applied to new features in the automotive industry. b) Even when additionally enabling Car-to-Fixpoint Communication (**C2FC**) applications, C2CC cannot well be introduced as an option. Considering the choices made today, it would need an unrealistically attractive C2FC application to be chosen by such numbers. c) No car manufacturer gain a competitive edge by pursuing the market alone.

Nevertheless, C2CC needs to pay off for the manufacturer to be integrated as a standard feature. To achieve this a mixed approach, with several beneficiaries, is proposed. As a basis, C2CC first of all needs to be perceived as a platform, which allows to realize a variety of applications relying on the wireless interface. The *one* attractive application does not exist. In the next step the system is divided into a basic C2CC functionality, which is integrated in all vehicles, and optional C2FC applications. C2CC applications can be sold only once the required penetration rates are reached.

These C2FC applications should be chosen carefully among those realistic to realize and of value to the customer. For the private owner infotainment applications like Car-to-Personal Equipment, Car-to-Home, Car-to-Hotspot or MP3 music downloads are of interest. Despite the mass the private owner represents, these applications have to be cheap to reach the market. The situation is different with fleet managers. They are looking *today* for solutions to improve their businesses and willing to invest in these. Electronic freight papers, electronic tachographs, delivery control in production plants as well as optimised rental car return processes are possible C2FC applications for them. Note that for the third group of applicants, the business users – who are generally seen as the typical early adopters – the introductory C2FC applications are of comparably little interest.

Additionally to selling the C2FC applications the car manufacturers can directly profit from the wireless interface integrated into the vehicle. Its existence can be exploited for the optimisation of the production process. Government agencies can also profit from the eC2FC

technology. The surveillance of e.g. the electronic tachographs as well as electronic tolling needs wireless solutions now.

It has been shown that there is a potential to successfully introduce the C2CC technology into the market. It requires though that the different players potentially interested in a wireless interface are coordinated, so that all can base their concept on the C2CC plattform. The respective harmonization should be brought about as soon as possible.

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