Mobility as a Service: On the road to packet switching

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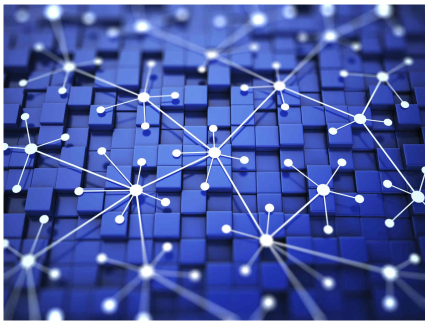


A few decades ago, telecom and internet spawned a new and disruptive socio-economic wave by bringing the marginal cost of communication and information sharing close to zero. This was largely made possible by a switch from circuit-switching to packet-switching networks. Information as well as voice and video is chopped up in small packets and flows over dynamically changing virtual highways and no longer over fixed wires. How can the key learnings from this revolution be applied to Mobility as a Service?

Containers are like Packets

Looking at mobility in all its forms, packet switching in some form is already in use. Logistic transport was one of the first to adopt the use of containers, hereby drastically reducing ship loading and unloading times and facilitating flexible transport on the road or by railway. However, ships transport containers in bulk with roads and railways still mainly operating like fixed connections.
Calculating how the space taken up by the railway or road is used over time, it can be seen that there is a lot of idle time, which ultimately underutilizes the potential capacity. True packet switching provides the capability to fill each packet to its own capacity and to transmit the packets as a continuous stream.

Applying packet switching to mobility

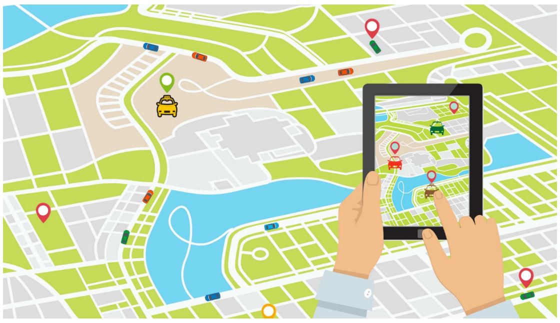
Hence, it is necessary to work on several levels. At the level of the packet, it is possible to use more of its capacity if all vehicles and containers are always filled as much as possible and are on the road all the time. This is what vehicle and cost sharing schemes can give us. This also allows the user to select the best transport means as he sees fit; small lightweight vehicles for short local trips, but taking mass transit transport when it is more cost-and time-efficient. Diversity is key.
Another difference is that packet switching equipment has a higher capacity than the incoming lines. On road and even public transport, this is often not the case. Roads merge over short narrow lanes or traffic is made to wait for traffic lights and very quickly intersections turn into bottlenecks, reducing the remaining throughput to a trickle. Hence, build high capacity road switches like roundabouts, under- or overpasses and eliminate traffic lights whenever possible. A four-way-stop can be more efficient, especially for local roads. Latency matters.
A third difference is that packet switching systems will group smaller packets in larger frames and put them on high bandwidth "highways". In terms of road transport this means vehicles and trucks connect and drive like a train, but because road vehicles are used instead of wagons on steel tracks, vehicles can join and leave when they need to. Automation is key.

Similarly, the internet architecture is distributed, decentralised and even redundant by design. There is no central authority that redirects each packet individually, but the routing is done locally. This is important or else a single failure can bring the system to a halt. On the road as well, it is better to have similar mechanisms. Everyone is aware of the situation whereby the navigation system proposes to all drivers the same alternative road that obviously becomes clogged up very fast. Decentralisation is key.

Packet switching works

Of course, even when packet switching is applied to mobility, it will not be possible to reach a zero marginal cost as contrary to internet packets, mobility entails moving weight and that requires a lot more energy, but it can certainly drastically reduce the cost by using the available capacity to its full extent so that we need less vehicles and less space on the road. A factor 2 to 10 is reachable (depending on the scenario). This can all be easily simulated so that the mobility industry can seek the optimal scenarios in the same manner as was done for telecom years ago. Cross domain fertilization pays off.

Packet switching for mobility: The cost AND ride AND vehicle sharing App



In the previous section, we advocated applying some of the principles of packet switching, the backbone technology of internet and telecom, to mobility and transport. After all, the similarity is clear. Packets carry bits, vehicles carry people and goods. In a first of a series of three articles, we'll explore some possibilities. We'll start by analysing the impact of sharing vehicles.

In packet switching there is essentially a separation between the physical medium, the packets as carriers and the payload. In mobility we have a similar situation. Roads are often owned by a public or private authority, vehicles are operated on those roads by companies or individuals and they carry goods and people.

In telecom or Internet, a packet is not really physical. It is a bit stream that carries encoded information. It takes a small amount of time on the medium and a little bit of energy to transmit and receive them. The transmission is provided as a service and many users share the same carrier.

How does this translate on the road?

In goods transportation, trucks transport for example, parcels and standardized containers. The latter for example drastically reduced ship loading and unloading times in our harbours. Still, often containers are moved around empty and many trucks drive around empty as well. Why? Mostly because the trucks and containers are owned by a specific entity.

When we look at for example cars, the situation is worse. Not only do cars spend most of their time being parked, when driven the average occupation is a mere 1.3 people per vehicle. Roughly speaking, we potentially could move 3 times as many people with the same amount of cars and potentially we could do with a lot less cars (if we would drive them instead of parking them).

Of course, this ignores that the demand has peaks during specific periods of the day. Fortunately, the fact that people often need to move at about the same time, gives us an important incentive to start sharing more vehicles.

Let us take as an example the widespread and typical traffic queues in the morning and the late afternoon. How many people living within a few blocks from each other are not moving all towards the same place where they work using the same roads? This is a good starting point because daily drive is boring, sometimes nerve racking and it is expensive.

How does the vehicle sharing App work?

Let us assume we all have an App (be it on the phone, tablet or home computer) that allows us to post our daily trips to a central server. The server could then try to match up people willing to share the ride. Only registered members would be allowed, so no unexpected surprises. Further more, the server could calculate (based on averages for the car's model) the real cost price of the trip and invoice each user, while compensating the car's owner. The latter doesn't even need to be the driver.

How could this work? First of all, the system will only work well if it has many members. This increases the likelihood of finding a match between the commuters. Secondly, the cost sharing will benefit all. No need really to make a surplus profit. The App sharing provider can be compensated by a small fee or membership contribution. After all, the cost price is low. Why, because the sharing App service itself makes heavily use of the already existing packet switching network of Internet and telecom.

Needless to say, if we can double the average occupancy of the cars, we could have half the number of cars on the road. Bye-bye traffic jams. The system works day and night, hence the roads and vehicles will be better used, but last longer. And of course, the same principle can be applied to transport of goods. A further extension of the App could be to include public transport options, especially important for cities as space there is at a premium.

Packet switching for mobility: measuring mobility efficiency

In earlier sections we advocated applying some of the principles of packet switching, the backbone technology of Internet and telecom, to mobility and transport. After all, the similarity is clear. Packets carry bits, vehicles carry people and goods. How should we measure its efficiency?

Mobility as a Service

If Mobility is a Service, then we should have ways to measure the service level. In the case of sustainable mobility, this is a fairly complex matter. Many criteria come into play and not a single solution can be optimal. In the end, it is a trade-off exercise. In addition, mobility as a service is a lot more than a story of vehicles. Vehicles need a road and energy infrastructure, both involving long term investments. The mobility service emerges as a mix of all these elements. Select the wrong mix and the economic impact can be dramatic.

So, let's go back to the basics. The goal is to move people and goods from a starting point to a destination. In other words, we must think door-to-door as this is the essence of the service. As to the solutions, we must also think "well to end-of-life". All the elements of our mobility eco-system will require resources. Resources to produce (materials, energy), resource to operate (energy and space) and if nothing can be recycled, the end-of-life value will actually be a disposal cost. Some elements are more difficult to calculate. For example, a vehicle also produces by-products while being operated: heat, noise and air pollution. Another issue is that mobility also involves time. Time as such is also a resource. It can indirectly be taken into account by measuring the average speed over a given door-to-door distance.

If we take all these elements into account, then the measure to compare becomes how much cargo (e.g. measured in kg) or people (assuming an average weight) we can move per unit of road (square m), per unit of production resources (measured in money value), per unit of energy used while moving for a given average speed. It is clear that this can be a mix of different types of vehicles (airplanes, ships, trains, buses, cars, etc.) but that the connection time must be included in the calculation.

Mobility as a density problem

From above, one can also see that during operation, mobility is essentially a "density" problem. Roads are fixed resources and we can only increase the efficiency by allowing more people and goods to be moved over them. This has several implications: smaller vehicles are better, driving closer is better, less vehicles on the road is better, less vehicles not driving but being parked is better.

It also means light-weight vehicles that can be recycled are better. After all, the law of physics remain valid: the energy needed is proportional to the mass and the square of the velocity. Hence, also the hidden costs like air pollution will be proportional to the mass of the vehicle.

What does it mean for electro-mobility? These vehicles have a very low pollution in heat, noise and air. And it is easier to automate them, even to let them drive autonomously. All things considered, this leads to scenarios whereby the vehicles are shared in time, else they use resources while not being used. A parked vehicle or one moving too slowly is actually very inefficient. They are also standardised as this reduces the production cost, but not necessarily by using composites and heavy batteries, but by using light-weight metals and small batteries. If we compare different vehicle solutions, than we see also that the defining classification depends on the average speed over a given distance. Hence, for longer distances, mass is less important because the energy is mostly used while accelerating to the reach a given speed.

Not just energy, mobility also requires space and time resources

While above observations are not really new, the inclusion of space and time used as a resource is often neglected because mobility is seen as a vehicle and traffic question and not as a sustainable service. When done, it leads to the concept of shared and small vehicles that are optimised for a specific environment. City cars are clearly not the same as open road cars, whether electric or not.

Packet switching for mobility: bringing it all together in the smart city

In earlier sections we advocated applying some of the principles of packet switching, the backbone technology of Internet and telecom, to mobility and transport. After all, the similarity is clear. Packets carry bits, vehicles carry people and goods. Let's now describe a scenario whereby all elements are brought together.

The scenario

First of all, we assume a reference environment whereby conventional vehicles (with internal combustion engines) are banned for entering the city unless there is no alternative. For examples heavy equipment and large moving trucks are not easily replaced with current electric equivalents. Depending on the city, public transport might still be available. This is less likely for small and older cities, but more likely for large metropoles. Important is that all transport is offered at real cost as else the best mix of mobility solutions is not likely to emerge.

People will most likely enter the city using public transport (e.g. by train or metro) or by car whereby they leave their big road vehicles at a large parking before entering city walls. Upon entering the city perimeter, people call up an App on their smartphone, enter their destination and a central server gives them all the options: public transport, taxibots or they can rent a small city e-vehicle, like KURT. The latter vehicles come in 2 shapes. One is 60 cm wide, the second one is 120 cm wide. They can move one or two people with a lot of cargo or two or four people with small cargo.

Mixing goods and people transport

Trucks and vans also stop at the distribution centres located at each large road entering the city. Unless too large, bulk goods or brought into or out of the city using standardised containers that fit on the KURT vehicles platforms. They come in two standardised sizes making it easy to stack them.

At the city entry point there is a continuous stream of KURT vehicles. Some come back from the city centre, some leave. Cargo and people transport is mixed and depending on the demand the KURT superstructure can be swapped between a cargo container and people "cabin". The latter can be optionally shared with the renting fee depending on the number of occupied seats or on the cargo being transported. This promotes the full use of the vehicle.

At these concentration points, the vehicles are quickly checked before they are boarded and start their journey through the city. They drive mostly autonomously at a limited speed. Whenever an unforeseen situation happens, a central dispatcher can take over using the on-board vehicle cameras while communicating with the passengers. When the vehicles arrives on its destination, it can be rented by another passenger and charge itself while waiting at the parking loading point. Given that the vehicles are small, each building provides the electricity and the owner gets a small fee on the electricity used. Some have solar panels on the roof or charge a buffering battery during the night when electricity charges are lower.

Mobility is sustainable when going electric

As the KURT vehicles are small, the road can handle twice as many as before and as they move around all the time, a lot of space is freed up for pedestrians, social activities and a lot more green. Music plays in the city only occasionally disturbed by a heavy vehicle. The air is clean. The smart city does not feel like a techno-hub, but one where technology operates in the background and non-intrusively provides the services that are needed in a sustainable, greener city.