# Position Statement: Future Wireless Cities

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Life in a city is dominated by constant negotiations between many of it's inhabitating actors. These negotiations can span many dimensions of time as well as group size, and the term actor should be defined rather broadly ranging from light-bulb to a philosopher's collective.

We can model this as a large number of agents which individually collect information about the world, process that information, and potentially act on the world, which in turn creates new information for all to collect - if they wish and are able to do so. The "cognitive abilities" required to successfully navigate city life will dramatically differ between a lightbulb in a closet and a taxi driver during rush hour.

One fundamental requirement for an agent to collect-decide-act is access to energy. Let's compare, as an example, two commute scenarios; a centrally controlled train system vs. autonomous self-driving cars. In this scenario, a train will only have to listen for simple instructions - "accelerate to 50km/h, stop in 30 seconds, ..", while the car has employ many sensors to construct its dynamic environment, negotiate with other cars nearby, consider laws and regulations,; and then finely control direction and speed. Ignoring the energy needed to move the vehicles themselves (that's why this isn't the greatest example) the train itself needs very little energy to control its actions, while the car clearly needs magnitudes more.

The reason for this elaborate introduction is my believe that emerging future architectures for a wireless city will largely depend on the **amount of energy we can provide all actors**. Actors with sufficient access to energy can locally process observed information and act on it while "limiting" communication to higher-level negotiations with other actors. Time-sensitive control loops can largely remain local leading to far lower requirements for a communication fabric than a world of centrally-controlled "dumb" actors which will require way more communication bandwidth and much tighter delay bounds.

There are many reasons that we should prefer a world of decentralised, loosely-coupled, smart actors. There is the biological inspired reason that a heterogenous system of differently evolving actors will be more robust. There is also the increasingly important aspect of privacy and individual determinism where each actor can now decide the benefits of revealing more information for a potentially better outcome, whatever that is.

Now, what is necessary to support a highly autonomous and decentralised world, we need to address the following challenges:

- Wireless transfer of energy
- Advanced ad-hoc communication (smart agents can keep negotiations "local")
- Mechanisms for devices to quickly bind to services and other devices based on complex selection criteria and within appropriate trust and confidentiality bounds (how much information am I willing to "publish" in order to find the right "partners")
- Negotiation and information dissemination protocols which are robust to uncertainty, inconsistency and incompleteness.
- Confidential computing mechanisms which confines released information to a specific interaction or negotiation (putting the Geni back into the bottle).

- Social, economic and legal foundation for allowing different collaboration models among different actors to emerge.

In summary, I believe that a city occupied by decentralised, smart devices supporting autonomous actors will provide a vibrant and robust environment for many innovative ideas to emerge which any city desperately needs to address the many challenges ahead. One of **the** key enablers for that is wireless power coupled with other new energy storage and harvesting techniques. Building on that we will need to provide the appropriate communication infrastructure which efficiently supports the interactions between all these actors while providing them with powerful mechanism to balance the need of learning about others while limiting the information released to others.

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What is deliberately missing from the above discussion is “bandwidth”. The current exponential growth in the data volume on mobile networks is primarily driven by video. While that growth will continue for some time, powerful devices and commercial drivers could even lead to a decline in video related traffic in the future. The potential drivers for that are the increasing use of computer-generated (CG) content on one hand and personalisation on the other. CG content provides the creative industry with ever more capabilities at decreasing cost when compared to shooting video with real actors in real-world environments. On the other hand, personalising content based on a user’s profile and context is considered by the industry a very powerful lever to increase engagement. Given the ever increasing graphics capabilities of end devices coupled with “algorithmically” created content could shift the final, personalised content creation to the end device, resulting in a dramatic decrease in the volume of data needed to be transferred to the devices in the first place. However, I have to admit that there are currently no indications that the current rate of volume increase due to video is decreasing anytime soon - so far the impending introduction of 4k/8k video and enhanced-reality “eye-wear” are clearly pointing the other way. But how much longer?