MOBILE INFRASTRUCTURES

A Comparison of the Systems of the Shipping Container and Mobile Phone

Jason Stewart
Matthew Heins

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Professor Paul Edwards
University of Michigan

Shipping containers and mobile phones share a common history with regard to their technological development. Although the former is not as technologically sophisticated as the latter, both came out of the post-World War II era and are characteristic in many ways of contemporary life. Each system is deeply expressive of the modern trends of mobility and globalization. In this comparison paper, the growth of containerization and of mobile telephony will be examined in both historical and theoretical terms. The paper begins with separate accounts of the historical development of each infrastructure, and then moves into a series of comparisons between them. (The historical overviews are fairly thorough, so that the comparisons can be drawn with an adequate context.) While the two systems share many common qualities, there are also some important differences between them. The similarities and the differences are both instructive, and help us gain a greater understanding of how these systems have affected our world today.

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The invention of the shipping container did not involve any technological or scientific innovations, but rather the creation of a new sociotechnical system that used existing technology in an innovative new fashion and revolutionized longstanding methods of freight transportation. The basic concept of the container—of carrying freight in a unitized and intermodal fashion—can be traced back to around the turn of the century. Large containers known as "lift vans," about 6′ wide and high and up to 16′ long, were carried on ships, wagons and trains. (Apparently they were mainly used by households who were moving and wished to ship their possessions—somewhat analogous to PODS and similar devices today.) With the rise of trucking in the 1920's and 1930's, some of the European railroads innovated with various small containers (around 4′-7′ in each dimension, and usually made of wood) that could be transferred between trains and trucks. In the U.S. a few similar attempts were made, but it became more common for railroads to carry entire truck trailers by "piggyback" service. In the late 1940's the American military came up with the CONEX box, a small (about 6′x7′x8′) steel box for use in global military freight movements on trucks, trains and ships.

These early intermodal containers were fundamentally different from the modern shipping container for three basic reasons. First, they were generally far smaller and less durable than contemporary containers. Second, their use was not managed or controlled in a systematic way that recognized them as conceptual units. Third, and most crucially, in most cases they were not parts of *systems* of freight movement. Rather, they were carried in an ad-hoc manner on existing modes of transportation, and transferred between modes using conventional equipment (cranes, forklifts, etc.) of the time. Few if any modifications needed to be made to the existing infrastructures or systems. The early containers were usually carried along with a mix of other cargo and goods—they were isolated objects in the broader stream of freight.

All this started to change in North America during the 1950's, as several shipping companies and railroads began to experiment with containers that in their size and method of use can be regarded as true shipping containers. According to Marc Levinson, the first use of modern shipping containers (admittedly a somewhat subjective and ambiguous thing to define) was by Ocean Van Lines in 1949 (Levinson 2006, p. 49). This company was located in the Pacific Northwest, as were two other innovators in containerization during the early 1950's, the Alaska Steamship Company and the White Pass & Yukon Railway. A few U.S. railroads also began to use containers, the most important being the New York Central. But it was clearly the success of Malcom McLean's new Sea-Land service, beginning in 1956 and operating along the Eastern seaboard and Gulf Coast, that gave containerization the critical momentum to grow rapidly. (Thus McLean is generally—though incorrectly—regarded as the inventor of the shipping container.) It should be noted that the Port Authority of New York and New Jersey provided crucial early support for Sea-Land, which used Newark as its primary port. Matson, a longstanding shipper between the West Coast and Hawaii, adopted containers in 1958, and the rush was on. In 1960 the Grace Line began the first international container service, operating between the U.S. and Venezuela. Though this service had to be quickly abandoned (due to resistance by longshoremen in Venezuela), others soon began international container shipping across both the Atlantic and Pacific. Companies in both Europe and East Asia proved surprisingly eager to embrace containerization, in fact, and the American advantage was short-lived.

During the late 1950's and early 60's the container was gradually standardized, in terms of its sizes and fittings, into the form it has today. This process was started by the Federal Maritime Board in 1958, and in the U.S. it culminated with the standards created by the American Standards Association in 1961. The International Organization for Standardization (ISO) accepted the U.S. standards, with some modifications, in 1965. The innovators in containerization had each used their own particular dimensions and fittings, and thus their systems were closed and incompatible, but with standardization it was possible for an interchangeable global system to come into being. This was crucial to containerization's growth. The use of computers to track and control containers, a trend that began in the 1960's but obviously has risen tremendously in detail and precision since then, has also been vitally important.

As containerization spread, the infrastructural elements used to carry and move containers were increasingly adjusted to better suit them. Trucks were equipped with chassis designed for containers (rather than simply tying them down on a flatbed truck). Ships were renovated or built from scratch with container "cells" that allowed containers to be placed in them and removed with ease. New cranes were built expressly for containers, and various straddle cranes and other devices were created to shift containers about and move them on and off trucks. The railroads were the last to adapt, but eventually they designed specialized railcars (and later double-stack cars) to facilitate container use. A humble device known as the twistlock played a key role in much of this, for it allows containers to be secured to each other, and also to various other things such as a truck chassis.

Since the 1960's containerization has expanded dramatically on a global scale, penetrating deeper and deeper over the world's terrain. This expansion has occurred in parallel with the growth of industries and factories, the development of modern transportation infrastructures, and the rise of ever more precise and extended supply chains. The infrastructure of the container has constantly been scaled up as well, with ships and ports in particular growing dramatically larger. The unique qualities of the container, especially its ability to span multiple transportation systems in a seamless fashion, have been exploited more and more effectively. In the late 1970's and early 80's American President Lines (APL) was one of the first to gain some measure of control over all modes of the transport chain, rather than just the ships. Other companies followed suit, and manufacturers and retailers came to depend on this speed, reliability and exactitude for their own operations. Just-in-time manufacturing, for instance, has been made possible largely by "the container, combined with the computer" (Levinson 2006, p. 267). Control over a supply chain can be exerted, with great precision, by white-collar office workers at locations far from the actual transport operations.

The prevalence of containers on the contemporary scene has led to all sorts of uses for them. In poor countries abandoned (or stolen) containers are often used for housing or informal retail, while in the First World architects churn out slick renderings of container housing projects (which somehow never get built). Sun Microsystems has developed a container with a computer server built in, for ease of delivery and overall convenience. Meanwhile additional standards have been created, to allow larger containers for domestic use within the U.S.

Shippers continue to utilize the container in new ways that exploit its qualities. Recently, for instance, some retailers are having containers delivered with a variety of needed products directly to their stores, rather than to warehouses. The goods are not just made in China, but are also brought to warehouses in China where they are sorted and placed with other goods in the appropriate container, which will go to a particular store in Europe or the U.S. Essentially the modularity of the container has allowed the warehouse to be moved from a more expensive First World country to a location where labor and space are cheaper. The only disadvantage is that the retailer must estimate what a store will be needing in about two to four weeks time (Taggart 1999, pp. 253-254).

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One can envision the rise of mobile phone (termed "cell phone" in the U.S.) service as an effort to end the informational "darkness" between communication points that had become a hindrance to the telecommunicative lifestyle. People had telephones at home and work, but for the other places where people tend to be—in the car going to the office, sitting in a restaurant, on the plane from New York to L.A., walking across the Diag—there was nothing.

Radio transmissions marked the beginning of wireless auditory communication, although this technology required no overarching infrastructure and connections between nodes were ad-hoc. Radio communication jumped into the spotlight with Guglielmo Marconi's wireless telegraph. In 1901 Marconi made news when he was the first to make a radio transmission across the Atlantic, from England to Newfoundland, with the support of a 500 foot kite supported antennae. Land communications were not the aim of Marconi's work. His company, Marconi International Marine Communication Company, marketed its products to the British Royal Navy and was used as a means of maritime communication. True mobile telephony did not enter the picture until quite a while after Marconi's wireless telegraph, but there were a few notable inventions along the way that attempted to bridge wireless and telephone technologies. The first was Lars Ericson's "car phone," which required a user to stop the car, climb a telephone pole, and patch into an existing telephone line; this was obviously not practical for most users. The second example, tested later in the early 1900s, was one of the first attempts to use "telephones" in a moving car. The batteries for devices like this were so large they often filled the entire trunk of a car, and were drained after only a few minutes of "talk time." It is during this period that we start to see the first attempts to integrate wireless communications technology and existing landline telephone systems, but the personal communication device we know as the mobile phone was still far off.

One of the early challenges of wireless communication, predating the widespread adoption of cellular technology, was the management and allocation of usable electromagnetic spectrum space. Initially regulation was done largely on a national level, which presented a problem: radio transmissions pay no attention to national borders and are only limited by their transmitter strength. With the growing popularity of radio service and ad-hoc radio communication, there arose a need for international regulation. The International Telegraph Union (ITU), which had already been established in 1865 to regulate fixed wire communication, was best equipped politically and technologically to facilitate this regulation, and became the international governing body for managing spectrum space and standardizing certain existing communication protocols.

In the wake of World War II there were significant strides in transmission and battery technology. Galvin Manufacturing Corporation (later to become Motorola) brought about a major advance in portable radio technology by using frequency rather than amplitude modulation; this significantly decreased the size of the equipment and improved its performance. Coupled with Bell Labs' introduction of the transistor, the stage was set for increasingly smaller devices (Cortada 2003, p. 177). As wartime production dropped off, research and development companies could focus on consumer applications of wartime technology. While telephony over the accessible radio frequencies of the time was not technically out of the question, the already crammed spectrum could not support the personal communications to which users of landline telephones were already accustomed. There was also political opposition against the integration of radio and landline telephone systems, and the FCC would not administer licenses to those seeking research approval for such hybrid systems. That finally changed in 1945 when AT&T successfully lobbied the FCC to grant the company a license to produce the first commercial mobile phone system, called the "Mobile Telephone Service," located in St. Louis and using radio telephone technology. Shortly after the implementation of this system, however, it became apparent that AT&T's allotted spectrum space would not be able to handle the demand—only 12 conversations could take place at a time!

Cellular technology was a promising solution to the dilemma of an overcrowded spectrum. The idea, developed in the 1940's by D. H. Ring at Bell Labs, essentially allowed frequencies to be reused once a mobile phone user left a communication cell. The more communication cells there were the more users the system could support, and a relatively small number of frequencies would be needed. Cellular technology met political resistance from the late 1950's to the late 1960's, as AT&T and Bell Labs unsuccessfully lobbied the FCC for about a decade to earmark some electromagnetic spectrum space for cellular testing. Some historians attribute the FCC's eventual reversal to the social and cultural shifts of the 1960's (McGuigan 2004, p. 83). Telecommunications of the mid-20th Century were hierarchical, paternalistic and sometimes even (in many areas of the globe) totalitarian, while cellular technology challenged these notions by promoting a model of less centralized control (Agar 2003, p. 37).

The first installation of a cellular network took place in Chicago, beginning on an experimental basis in 1978 and commercially in 1983. Its success caused the FCC to decide that mobile phone service should be deployed systematically nationwide. 180 licenses were to be awarded to the largest metropolitan areas, but due to a period of application submission hysteria (90,000 applications were received) review of every application was nearly impossible. The top 30 metropolitan areas were issued licenses, and the rest assigned by lottery. Only regional operators, including the "Baby Bells," were permitted to request licenses, and this resulted in an extremely disjointed network; roaming (i.e., making calls on a network other than that of your provider) was very difficult since each company was free to develop mobile phone networks according to whichever standard they chose. An analog communications framework known as AMPS (developed and maintained by AT&T) provided a very basic and loose guide for how "terminals" should interact with base stations, but there was enough flexibility in this technology that many incompatible systems existed. Nevertheless a basic infrastructure of mobile phone service was being built up and expanded, albeit slowly.

The consolidation and standardization of American mobile phone networks took place in the early 1990's, as the era's largest operator, McCaw Cellular, bought LIN broadcasting and 90 other operators (and hence, their licenses). AT&T then bought out McCaw in 1993 for about $11 billion. Having achieved consolidation of most of the nation's regional carriers, AT&T could now impose standards to ensure universal service. Needless to say, this proved a tremendous stimulus to the use of mobile phones. Gradual improvements to the quality of the service, as well as the phones themselves, were also crucial; mobile phones grew smaller and gained more features, while their geographical coverage continued to expand. Over the 1990's they penetrated deeply into American life, a trend that has continued even further in the current decade. With few additional users to be gained, and further advances in the technology, the emphasis has turned to additional features, so that today the cutting edge is with Blackberries, IPhones, and other devices for which mobile telephony is only one of their many functions.

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A comparison between the shipping container network and that of mobile phones brings to light many informative similarities, differences, parallels and contrasts. Precipitated by globalization and the desire for mobility, both systems can be regarded as emblematic of our postwar era. For mobile phones, the main benefits of the postwar period were the advances in technology, some of which actually resulted from the war itself. In the mid-to-late 1940's Motorola made significant advances in both frequency synthesizer and battery technologies, paving the way for smaller wireless communication devices (namely, at the time, the Handie-Talkie and Walkie-Talkie). The realization of frequency modulation (rather than amplitude modulation) also allowed wireless communication devices to be smaller and hence portable. In contrast, the container did not result from technological innovations, in general, but rather from broader changes in the organization, standardization and economics characteristic of the postwar era. It is interesting to note that the U.S. military began to experiment with some tentative forms of containerization during World War II, which eventually became their CONEX container system; thus both the mobile phone and the shipping container derive in some small part from the war.

The growing networks of containerization and mobile telephony have both roughly followed the model set forth by Thomas Hughes for the evolution of a large technological system (LTS). Hughes proposes five stages in the development of an LTS: invention, development, innovation, technology transfer, and growth, competition and consolidation. The invention period is marked by the initial conception and first iteration of a device that will later become the critical component of the overall system. In the case of shipping containers, the invention is merely the idea of the container itself, and the associated concept of unitized freight transport across multiple modes. As noted above, there was virtually no real technological or scientific advancement involved in such an idea—containerization is a change in methods and practices, not a revolution in technology. (Thus there was nothing self-evident about the success of the idea, and it had to be introduced several times before it actually picked up steam.) In the case of the mobile phone it is a bit more complicated to determine what actually constitutes the invention stage, for there were several devices and systems that failed, each in turn giving birth to more refined ideas. But the period of events that most closely fits into this stage would probably be the test implementations of the radio telephone in the mid-1940's.

The development stage of containerization would be the progress that Malcom McLean made in fully conceptualizing his concept. His initial idea was actually to carry truck trailers on ships, but he revised this by dropping the wheels and converting them into containers (though he generally still called them "trailers," and even called his new ships "trailerships"). In addition he began to think about how these containers would actually be carried in ships and on truck trailer chassis. For the mobile phone, the development stage is AT&T's "Highway Service" between Boston and New York in the mid-to-late 1940's; this represents the implementation of an early version (ultimately abandoned) of mobile telephony.

During the innovation stage of containerization in the mid-to-late 1950's Malcom McLean started to build up his Sea-Land system, using his own company's ships and the trucks of companies that contracted with him. (When McLean moved from trucking into shipping he was forced by government regulations to sell off his trucking business—but presumably he had many contacts in the industry.) In theory the system was intermodal right from the start, though in practice this took some time to develop. In relation to mobile telephony, the innovation stage comes with the advent of cellular technology, which allowed the reuse of spectrum space between communication cells. Prior to this, there was no way to manage numerous personal and private communications on the crammed electromagnetic spectrum.

For the container the stage of technology transfer is marked by the adoption of containerized shipping by McLean's competitors. The first shipping company to follow McLean's lead was Matson, though the New York Central Railroad also started to use containers that could be transferred between railcars and trucks. In contrast to such corporate entrepreneurship, the FCC's decision to finally license regional cellular providers exemplifies this stage for mobile phones. After the successful creation of the first commercial cellular phone system in Chicago, the FCC was convinced of the practicality and feasibility of the concept, and deployment under its supervision soon followed in other major cities.

The stage of growth, competition and consolidation, in the case of both the shipping container and the mobile phone, is characterized by global standardization, growth, and interchangeability. No longer were Sea-Land, Matson and the other pioneers of containerization using closed incompatible systems—now that the dimensions and fittings of the container were standardized across the industry, any shipping company could take advantage of access to ports and streamlined exchange and delivery mechanisms. Likewise with mobile telephony, standardization and interchangeability helped drive the boom in the system's use. This took a substantial amount of time in the U.S., however, due to the many regional carriers, the competition between them, and the lack of government intervention. The industry itself eventually enforced standards, through the consolidation of many regional carriers by AT&T.

One important similarity between containerization and mobile telephony is that both function as what Erik van der Vleuten refers to as a "second order large technical system," a term he borrows from Ingo Braun (Van der Vleuten 2004, pp. 404-406). Such a system can be viewed as an infrastructure in its own right, but it rests upon a more "basic" system or infrastructure. Most second order systems, in fact, rely upon several such systems, and derive their value from their ability to span and draw upon these basic "first order" systems. In Braun's original example, the European organ transplant network, that is certainly the case. Shipping containers likewise constitute a second order system that gains its value from spanning a number of basic systems. Most crucially, containers can be carried on the (previously separate) systems of shipping, trucking and railroads. In addition, container movement today also relies on systems of data communication and storage.

For mobile phones the case is somewhat different; the mobile phone network gains its value essentially from plugging into a more basic and pre-existing system, that of landline phones, and expanding the system's spatial reach. At least in the beginning, mobile phones did not span multiple systems. That has changed in recent years, as the phones increasingly are able to access the internet and GPS networks. Still, the value of the mobile phone does not lie primarily in its ability to access these networks simultaneously, but rather to do so at any location within the geographic coverage that cell towers provide. By contrast, containers in their own right cannot push any further into uncharted space; they depend on ships, trucks and trains for that. The value of containers rests primarily on their ability to be carried by multiple modes of freight transport, as well as the seamless transfers they provide between those different modes. Both containerization and mobile telephony, therefore, fit into the basic rubric of a second order system as van der Vleuten describes it, but they are significantly different types of second order systems.

Another similarity of containerization and mobile telephony is their use of "gateways" to make their networks possible. The gateway concept, as put forth by Tineke Egyedi, emphasizes the critical role of some universal standard in welding two or more disparate systems together. The gateway provides a commonly agreed-upon interface between otherwise incompatible systems, and the existence of this standardized interface actually allows tremendous flexibility within the systems themselves. As Egyedi herself points out, the container is the gateway that binds together various systems (shipping, trucking and railroads) into one overarching network of intermodal freight transportation. For mobile phones, the gateway they depend upon is the cell tower (and its associated technology) that links them into the main (i.e., landline) phone system. This main phone system is necessary not merely for mobile phones to communicate with landline phones, but also for mobile phones to reach each other. In the case of containerization, by contrast, each of the individual transport modes can of course function in its own right.

For both the shipping container and mobile phone infrastructures, the role of information and hence information technology in the tracking and control of the constituent parts is crucial to successful operation. Keeping track of the location, movement and cargo of containers (each of which has a unique indentifying number marked upon it) is critical to the efficiency of the shipping process. The largest ships can carry a few thousand containers, and at major ports the numbers are obviously far greater. From an organizational and logistical standpoint, the management of so many containers is increasingly difficult as their numbers grow—advanced computer systems become desirable to handle the job. With mobile phones, the role of information technology is less about ease of management for an otherwise manual task; rather it is a technological pillar of operation. The technology requires a "hand-off" of the mobile phone user's call between communication cells. In order to insure that each call that is handed-off between cells is continued, the mobile phone must have a unique identifying number (as with each container) to distinguish it from others. Additionally, the switching of frequencies between communication cells must take place instantaneously; otherwise the mobile user's conversation will be interrupted. The implementation of information technology to handle this "hand-off" is crucial to the operation of the system.

One key fundamental difference between containerization and mobile telephony is that the former is an eminently physical system, while the latter is an intangible system of radio waves on the electromagnetic spectrum. The shipping container itself is an object of great size and bulk, while mobile phones are prized for being small and lightweight. The digital technology embedded in the phones themselves, as well as in the networks they depend on, is also an ethereal, less tangible sort of technology. The intangible and lightweight character of mobile telephony is in large part why many see mobile phones as emblematic of contemporary life. But it is important to remember that containers, while they have a largely "backstage" role in today's world (and possess a generic quality that often helps them escape notice even when in plain sight), are equally paradigmatic of our times. The endless flow of material goods they bring us underpins our high quality of life—and wasteful habits of consumption.

Our existence has been augmented by digital networks, communication flows, and virtual realities, but it is still a highly physical world we inhabit. Mobile telephony symbolizes the intangible (virtual, digital and lightweight) side of our lives—the new "information age"—while containerization represents the enduring importance of the physical and material. Yet if one looks deeper, an ironic reversal becomes evident. Mobile phones depend on a physical infrastructure, that of cell towers, landline networks, switching stations, and the other physical elements that compose a telephone system. Containers meanwhile are guided and tracked by communication networks, primarily of an electronic and/or digital nature, that have become essential to their proper movement. Thus in both systems it is evident that the physical and the intangible—material things on the one hand and digitized information on the other—are each necessary. It would seem reasonable to propose that this is now true of most of the systems and infrastructures which structure our contemporary world. Perhaps this is one of the most important lessons to draw from the comparison of containers and mobile phones, two very different devices that nevertheless have many parallels between them.

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