Ubiquitous computing offers an unprecedented framework for innovation to cycle between the Computer and Social Sciences. This cycle begins with the tools of Computer Science. Commercial mobile phones effectively function as sensing platforms, effortlessly creating massive datasets. Machine learning and data mining provide powerful analytic lenses to examine this so-called "Big Data," observing and measuring people in ways previously not possible.

For example, in previous ethnographic studies, modern families describe managing children's transportation as a major cause of anxiety. The mobile phone data I collected literally paint a picture of family coordination (see Figure 1). Big Data help explain qualitative findings. Unexpected plan changes cause parents the most anxiety, and we can see, using this data, that less than 20% of all days involve no unexpected changes.

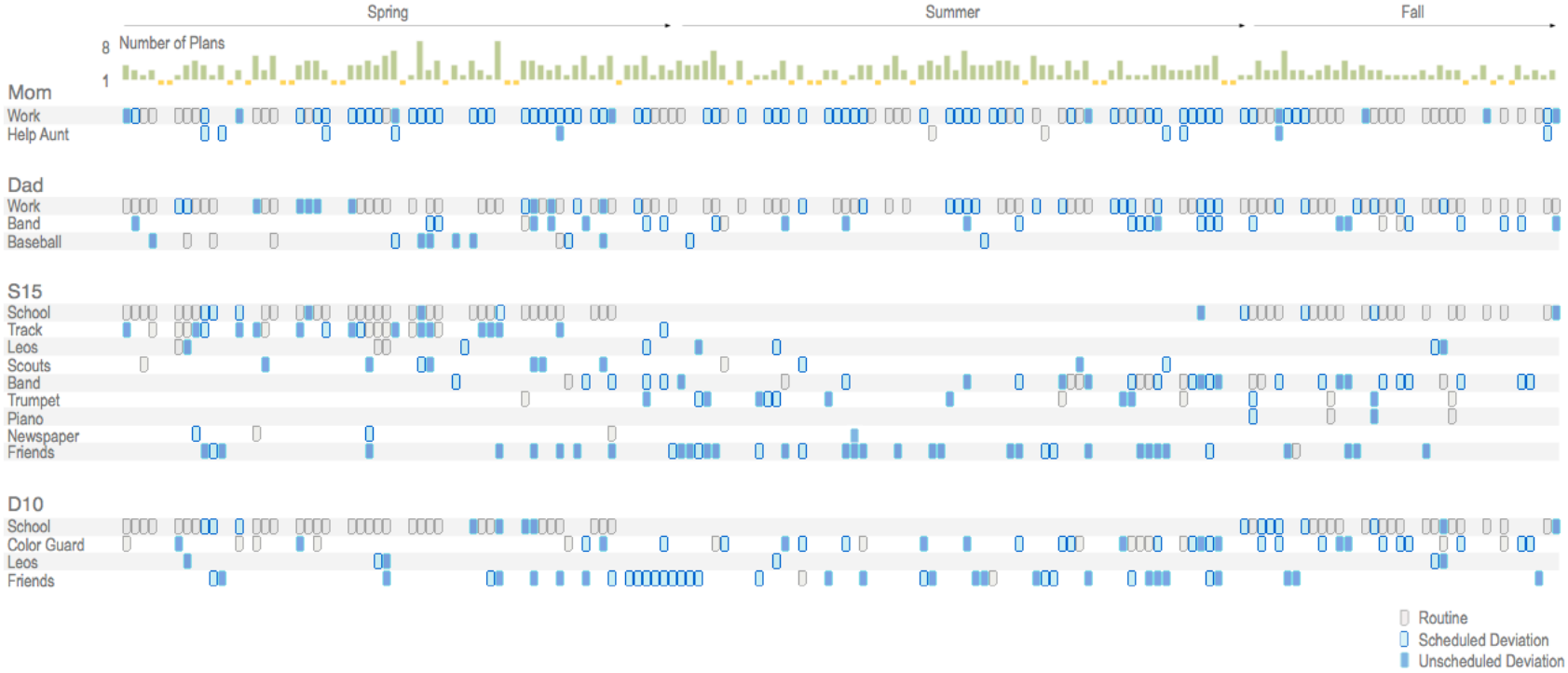

Figure 1. Six months of activities and transportation for one family, taken from the longitudinal data collection on mobile phones. Each dot represents an activity instance, ordered chronologically left to right, and classified as either routine, or scheduled or unscheduled deviation. Proportion bars to the right of each activity show the distribution of event types. Across the top is the number of plans created that day. Days with no plan changes are colored orange, and days with plan changes in green.

Big Data also allowed me to explain certain coordination breakdowns. Family members often need to adapt logistical plans to changing circumstances. They do not always, however, have complete or up-to-date information about plan details – like other family members' locations and intentions. Because family members use calendars to document mostly non-routine events, no information resources exist to find the details that are critical to making reliable plans.

Ubicomp also creates new opportunities to do Computer Science research that serves people. Big Data allowed me to introduce new models of family coordination. With only mobile phone GPS, we can sense when parents pick up and drop off their children at over 90% accuracy, predict which parent will make the next pick-up for an event with over 85% accuracy, and even predict if a parent will leave a child awaiting their arrival at an activity.

In real-time, we can combine Big Data with predictive models to enable new classes of application. For example, I created a new way to visualize calendar data. This Family Time-Flow (FTF) illustrates the family's plan between 3pm and 8pm (Figure 2, left). To follow Mom's day, we trace her path from left to right across the diagram. Mom (magenta) plans to leave work at 3:45pm, arriving home at 4pm. At 4:30pm, Mom drives her 7-year-old daughter (D7, yellow) to swimming, drops her off, and then returns home. A more complex (Figure 2, right), the FTF makes clear that if Mom (yellow) leaves any later than 5pm, her 11-year-old son (S11, cyan) will be late for his basketball game. Dad (green) plans to pick up D7 (magenta) from Karate at 6pm, and Mom plans to pick S11 up at 7pm. But because their previous location is hard to predict, the FTF draws a semi-transparent line from nowhere.

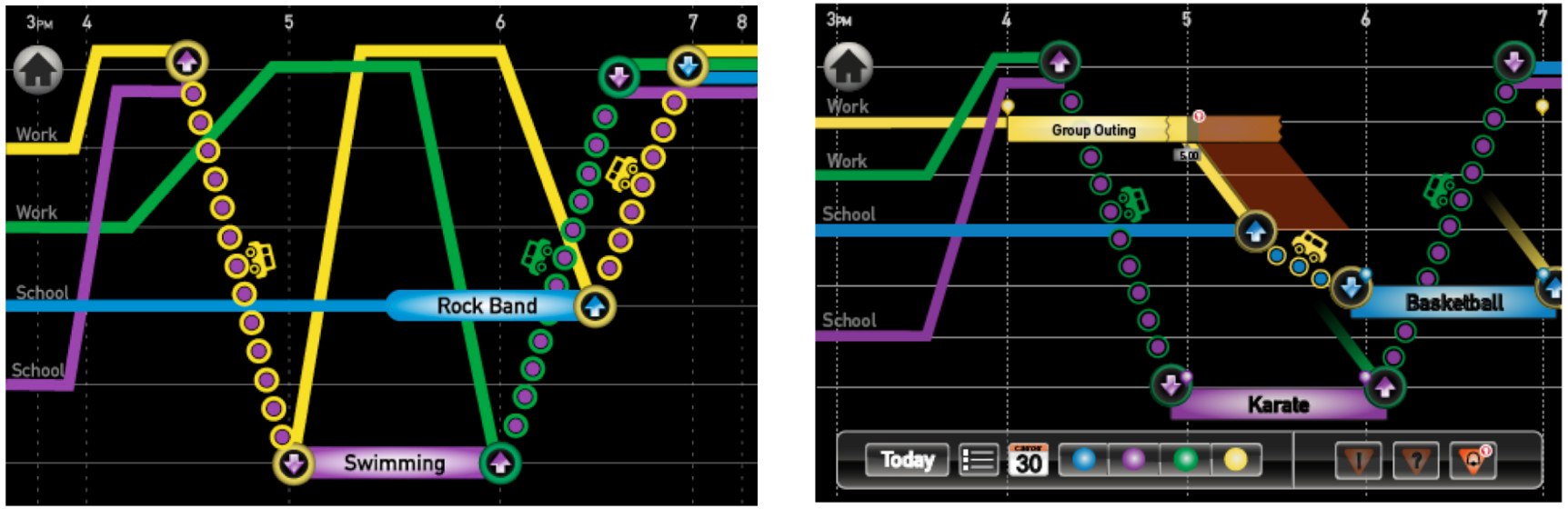

Figure 2. In the basic symbology of the FTF, colors are people and the x-axis is time. A colored horizontal line means a person is at a place. A diagonal line means they are traveling between places. A thick horizontal line means a schedule event is happening at a particular place. Special symbols indicate when parents give children rides. The up and down arrows indicate the location of pick-ups and drop-offs, and the diagonal dots indicate co-travel, or travel with parents and children together. Ambiguity is encoded as transparency, and transparent orange areas indicate time ranges that could lead to late outcomes.

This new class of applications faces unexpected challenges. Translating human values into systems that serve people is not a straight line. When carpool plans break down, I have observed parents anxiously phoning friends, frantic to make new plans. Simulate a system to re-plan carpools, however, and parents feel replaced, violated, and out of control. In Ubicomp systems, functional needs interact with social values. Deployed systems risk bumping against these unexpected interactions.

To avoid this kind of failure, I developed a technique called Speed Dating (SD). SD offers a way to simulate how users experience not only how applications function but how they interact with social values. If adoption is the yardstick for success, the method is now part of the HCI curriculum at Carnegie Mellon, Stanford and Wisconsin and practiced at companies like Google and Microsoft.

Ubiquitous computing becomes a powerful partner to do basic research in the Computer and Social Sciences. Big questions appear when we point its analytic lens at many subjects: how will big data change health care?; and what primitives will people use to access invisible services?

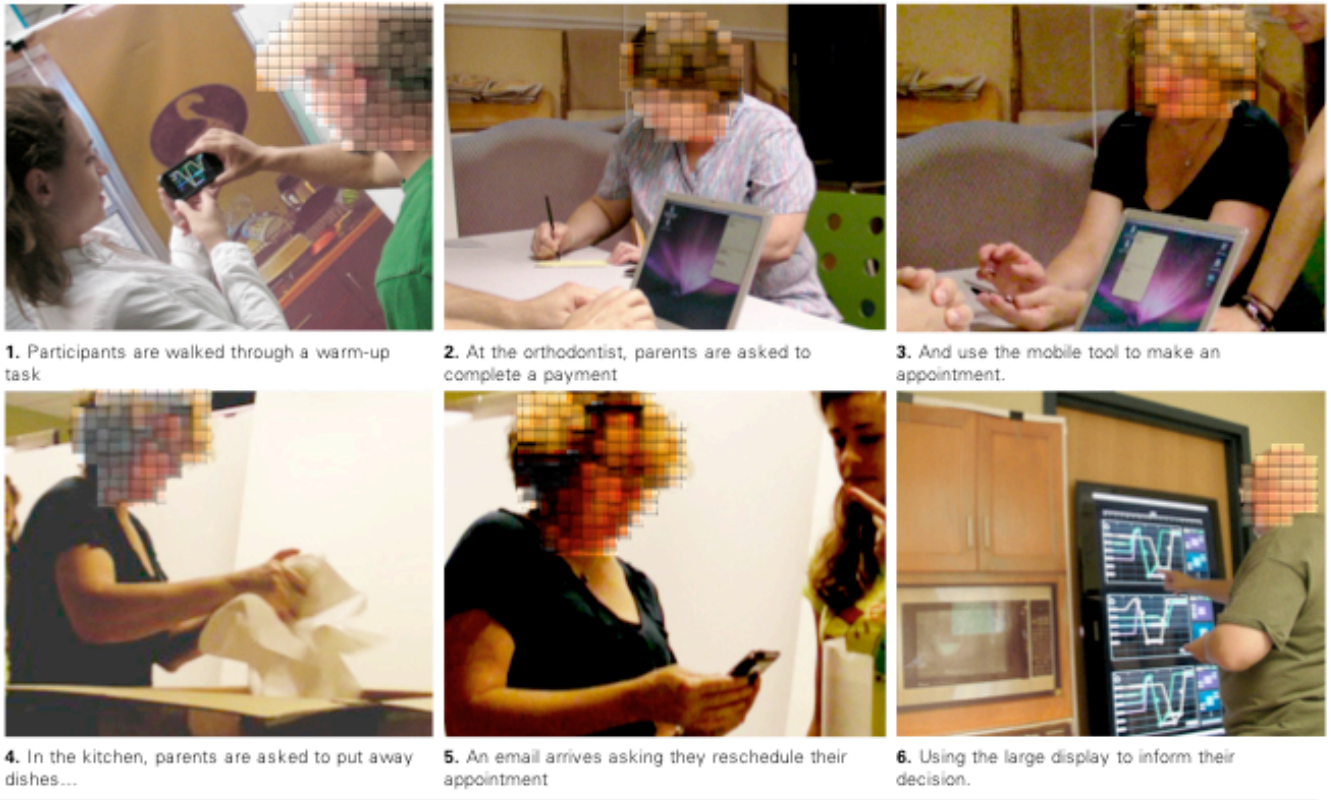

Figure 3. Two scenarios showing parents during an experience prototype. The top row shows a mobile scenario, where the participant is at the doctor's office, using an i-Phone app. The bottom row shows the FTF on a large screen in a simulated kitchen.