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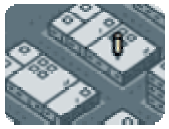
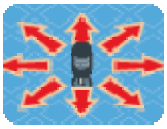
ShotSpotter

Last year there were 148 homicides in Oakland. Today, when someone fires a gun on a city street, a network of hidden microphones kicks in — triangulating the exact location. And alerting police. Can a tech startup help put a dent in violent crime?
By Ethan Watters

Shot Spotter



Ears on the Street
http://www.wired.com/wired/archive/15.04/shotears.html



Spotting the Shot
http://www.wired.com/wired/archive/15.04/shotsp

On a chilly January evening, police officer Abdullah Dadgar is giving his new partner a tour of Oakland's notorious east side. "There was a shooting in front of that liquor store, guys firing AK-47s," he says, steering his squad car past dilapidated buildings and sidewalks strewn with refuse.

A few moments later: "There was a homicide in that alley over there." Then: "The Norteños had a gang war around this area." He goes silent for a while and adds as an afterthought, "There's been a shooting spree on pretty much every block we just passed."

Dadgar's partner shifts uncomfortably in the passenger seat. He stares wide-eyed at the gangbangers and prostitutes congregated on every other corner. Occasionally he glances down at the Panasonic Toughbook in his lap. A computer programmer who recently moved to California from China, Stanley Bai has never been in a police car before. He's riding along tonight to test a new software program.

The computer is running the mobile version of a gunshot-location system. If someone discharges a firearm within Dadgar's patrol area, sensors scattered around the neighborhood will pick up the sound, enabling a central server to determine its origin and relay the information to Bai's laptop. Oakland dispatchers have been using the system, known as ShotSpotter, for a couple of months, but this is the first time that ShotSpotter alerts have been routed directly to a laptop on the street.

Oakland police are in dire need of this kind — or any kind — of assistance. The city saw a 68 percent jump in homicides last year, for a total of 148 deaths. Last August, officials

hauled away illegally parked cars and painted over gang tags in the most troubled areas, hoping that a crackdown on petty crime would hold the line against violent crimes, as well. It didn't work. The next month, 19 people were shot to death.

So the police decided to take a high tech approach to the problem. In October, the department spent $350,000 to install 84 ShotSpotter sensors on rooftops, utility poles, and other inconspicuous places over 6 square miles of urban blight. Since then, dispatchers have received roughly a dozen automatic alerts every day, each one an opportunity to get officers to the scene of a shooting while the gun is still smoking.

The system is so new that the department hasn't yet worked out procedures for integrating it into standard operations. The top brass is nervous about sending officers into the line of fire without taking time to call in reinforcements. So, rather than immediately routing ShotSpotter reports to patrol cars, dispatchers have been letting the alerts stack up along with other second-priority calls.

But technology moves faster than bureaucracy, and the mobile upgrade has arrived ahead of revised protocols. The software Dadgar is testing tonight routes information around the dispatchers, letting the cops themselves decide how to handle ShotSpotter alerts. Just last week, Dadgar's lieutenant counseled him to treat every alert like he was going up against a sniper with a rifle. Don't rush to the scene alone. Wait for backup.

Preoccupied with a half-dozen critical tasks — watching the street, checking suspicious vehicles, deciphering a constant stream of radio chatter — Dadgar pays little attention to the ShotSpotter interface. Cops love a good piece of equipment, but they're looking for utility. They'll talk at length about the merits of a Surefire LED flashlight over the conventional Maglite, which can break a bulb if it's dropped, or about the simple design of the Glock 22. To earn respect, a piece of gear must work reliably when officers are "raised up" — that is, when life is on the line, adrenaline is surging, and every split second counts.

At exactly 9:01:22 pm, Bai's laptop sounds a whooping alarm. "It's saying it heard a single gunshot," Bai says. Dadgar pulls over and studies the laptop's display, a street map overlaid upon a high-quality aerial photo. A red dot shows where the shot was fired — just a few blocks away. Then Bai clicks on a button to play back a recording of the incident. "That's a gunshot," the officer confirms. He radios for backup and hits the gas.

As the car speeds down narrow streets, Bai grips his laptop and watches the software go to work. A little police car icon moves closer to the red dot, and the program automatically zooms in on the location. The Google Earth style aerial photo gives Dadgar a bird's-eye view of the neighborhood, down to backyards and hidden alleys.

The squad car reaches the scene within minutes, but the shooter seems to be gone. Driving slowly, Dadgar shines his spotlight along the hedges. Finding neither perpetrator nor victim, he radios a code four, calling off the sirens that are quickly closing in.

Dadgar stops the car and takes a closer look at the laptop. "I'd ride with this piece of equipment," he says, nodding his approval. But shouldn't he have waited for backup? "With this technology, it's kind of like hearing the gunshots yourself. You're going to want to respond."

Sitting in front of five computer screens at ShotSpotter headquarters in Santa Clara, California, field application engineer Dana Kirsch is conducting a virtual flyover of US crime capitals. She pulls up an aerial image of Gary, Indiana, its grid marred by 15 crimson dots, each representing gunfire picked up by sensors during the previous week. Then the so-called "fatal crescent" district of Rochester, New York, bearing 23 dots; Washington, DC, 33 dots; and finally Oakland, with a chilling 111 blood-red marks.

Even viewed from a few thousand feet in the sky, these places look downtrodden. Vehicles languish in dirt front yards. Vacant lots stand out like missing teeth.

On the map of Washington, DC, Kirsch points out an apartment complex where four shootings took place in less than 12 hours. Four separate reports appear on a numbered list. Each item includes the time, nearest address, and incident type — single or multiple gunshots, firecrackers, bottle rockets, and other sound sources. She selects a report from the list and a graph appears showing the sound's waveform. She plays back the four recordings in turn: three sets of multiple shots and one single round. The series of five fired at 11:27 pm are close together. They sound hurried.

All too often, a shooter doesn't need to rush. A quarter to a half hour can pass before police respond to a call reporting gunfire — if anyone calls at all. Many shots fired in urban areas go unreported. When sheriff's officers in the Willowbrook neighborhood of Los Angeles County tested the system, they fired boxfuls of blanks and live rounds in nine separate areas. Hardly anyone noticed. The patrolmen shake their heads when they tell the story, repeating the key details: nine locations — more than 100 rounds discharged — and only a single phone call. They reckon that citizens are either distrustful of the police, fearful of retaliation, or simply inured to the frank *pop pop pop* of gunfire.

Even if someone does report hearing gunfire, the chance of identifying the location and catching the perpetrator is remote. Echoing off walls and masked by other noises, the sound's origin can be difficult to place.

That's where ShotSpotter comes in. "In the past, the best information the police could hope for was a neighbor calling to say, ‘Sorry to bother you, but there may have been a shooting somewhere in my neighborhood,'" says ShotSpotter CEO James Beldock. "Our system can immediately tell them that, say, 11 rounds were fired from a car going 9 miles an hour, northbound, in front of a specific address on Main Street. In some situations, ShotSpotter could get someone on the scene within a minute. That's a level of situational knowledge police have never had."

This kind of coverage requires an array of 12 to 20 specialized sensors per square mile. Roughly the size of a medium pizza and designed to look like a rooftop fan, each sensor contains up to four small microphones. If one of these units detects a loud noise, it forwards a recording to a server at police headquarters along with three pieces of information: location, time, and general direction the sound came from. If a sound is detected by only one sensor, it's probably too quiet to be gunfire, and in any case, the system needs data from three sensors to pinpoint the location of a noise. If several sensors report an event at the same time, the server gets to work. First, the software performs an analysis to categorize the noise as gunfire, firecrackers, bottle rockets, helicopters, or other. If it determines the event was a gunshot, the program makes a simple calculation to triangulate the sound's origin to within 80 feet or less.

Experienced ShotSpotter users can tell a lot about an incident by listening to the recordings. Some say they can distinguish between the pop of a handgun, the crack of a rifle, and the emphatic blast of a shotgun. The company plans to update the software to recognize these variations automatically.

Kirsch believes the sound can even reveal a shooter's state of mind. Selecting a red dot in Gary, she plays back the digital file. At 8:47 pm, sensors on Clark Street picked up the beats of a large-caliber weapon firing five times. The first two shots are spaced by nearly a second; the last three occur in quick succession. The distinctive two-plus-three pattern, she says, sounds like the work of a determined killer: Take aim, get the target down, finish him off.

ShotSpotter got cops to the scene quickly that night, but it was too late. All they found was the victim's lifeless body.

Violent crime rose dramatically between the late 1980s and early 1990s, a decade before the trend unaccountably reversed in a shift that still baffles experts. During that period, Robert Showen was working as an engineer for SRI International, a high tech think tank on the outskirts of Silicon Valley. His office was just down the road from East Palo Alto, an area plagued by gang killings and drive-bys. When the neighboring town was declared the "murder capital of the nation" in 1992, Showen was compelled to take action.

"I hadn't worked with sound waves before, but the idea of using them to triangulate the location of a gunshot seemed so elegant," he says. "In principle, the problem should have been easy to solve."

Showen started a company to commercialize the concept in 1996 and set out to find his first customer. It wasn't East Palo Alto but the nearby community of Redwood City that served as the test bed. The town wasn't known for violent crime, but it did have a problem with firearms: A disconcerting number of residents fired their guns into the air on Cinco de Mayo, the Fourth of July, and New Year's Eve, showering the area with bullets.

When Redwood City rolled out the ShotSpotter system in late 1996, authorities bragged to reporters that if anyone fired a gun within city limits, the police would be there in moments. The message sank in. Over the next couple of years, celebratory gunfire dropped by about 75 percent. This came to be known at ShotSpotter as the "common-knowledge effect": When trigger-happy citizens think the police are listening, they are less likely to indulge.

From a technical standpoint, though, the Redwood City installation wasn't so successful. In tests, it located gunshots only 45 percent of the time. Moreover, percussive sounds like pile drivers and slamming dumpster lids confused the software, triggering alerts when no shots had been fired.

This put ShotSpotter in an awkward position. The product had proven remarkably effective — but that was due to good PR, not good technology. On the strength of Redwood City's holiday results, the company sold systems to cities in Arizona, South Carolina, and Southern California. But false alarms remained common, and there were other problems. Sensors went dead without warning. The software that displayed gunshot locations ran on the same central computer that performed the audio analysis, making it difficult to distribute the information to an entire police force. The company was so understaffed that Showen, acting as CEO, CTO, and chief of sales, found himself handling customer complaints.

In 2003, with the company on the verge of collapse, Showen hired Beldock, a young turnaround specialist, to revamp the management. The founder retreated to his lab while the new CEO raised funds to hire additional engineers and programmers. Two years later, the company merged with Centurist Systems, which was researching gunshot-location technology for military applications. Centurist owned a deceptively simple patent that described how to use the clock built into global positioning satellites to triangulate the location of a sound. ShotSpotter took advantage of the technique to design a new generation of smarter sensors.

The upgrade caught on fast. Chicago, Gary, and Washington, DC, bought systems in 2005 and 2006. The revitalized sales staff called the LA County Sheriff's Department just in time. "I had the memo on my desk to cancel the whole program when the new management called out of the clear blue sky," says Sid Heal, a commander who oversees new technology for the force. "They said, ‘I know we're in damage control mode.' I told them, ‘No sir, you're in life-support mode.'" Determined to regain his trust, the company replaced LA's sensors for free. Heal says the department has been so pleased with ShotSpotter's improved effectiveness and tech support that he's thinking about extending coverage to the notorious Compton district.

Meanwhile, ShotSpotter expanded from the mean streets of the US to the blast zones in Iraq. In 2006, the Army deployed a specialized battlefield version. The user interface is mobile, and so are the sensors themselves; soldiers carry units roughly the size of a Tom Clancy paperback. The sensors pinpoint enemy fire while a camera on an unmanned Boeing scan Eagle aircraft overhead targets the threat. The company is hoping the

common-knowledge effect also applies to guerrilla warfare. "If a sniper gets vaporized after he takes his first shot, word is going to get around among insurgents," says ShotSpotter's military liaison. So far, he adds, thanks to the system at least one insurgent sniper has been "neutralized."

The improved sensor arrays deployed in US cities show even more promising results. Two days after Rochester, New York, activated 6 square miles in July 2006, local police arrived on the scene of a shooting in time to make an arrest. Since then, the array has been solely responsible for roughly one gun-related arrest per month.

The 2-square-mile grid in Gary recorded 10 to 15 incidents a day when it was installed in 2005. Police used the system to confiscate 45 illegal weapons on New Year's Eve of that year, and shooters began to think twice. Now the system picks up one or two hits a day.

ShotSpotter doesn't just lead to arrests. In several police shoot-outs, the technology has been used to contradict witness testimony that cops fired first. In other cases, alerts have led police to victims who likely would have perished without prompt attention.

Just before the end of Abdullah Dadgar's shift, the computer in Bai's lap begins whooping again: multiple gunshots on Monticello Drive. Dadgar doesn't hesitate. He starts up the siren and takes off. The car reaches the scene within two minutes, but once again the shooter is already gone.

Driving back to the Eastmont station, Dadgar acknowledges that the night's calls — and his decisions to respond immediately — were risky. But he sees an upside as well. "Even though I'll get there faster, I'll have more information. Less chance of turning a corner and being surprised," he says. "When you roll on a ShotSpotter call, you're going to be raised up and ready."

Still, with reaction time cut down to minutes or seconds, it's inevitable that some ShotSpotter alerts will turn deadly.

On February 3, three sensors picked up gunfire at 1:49 am. A red dot on the map appeared just blocks from the Eastmont station, and officer Martin Ziebarth, who was there filling out paperwork, rushed out into the night. A few minutes later, he came upon 21-year-old Addiel Meza walking down the street with the butt of a pistol sticking out of his pants pocket. Ziebarth stopped his car, jumped out, and yelled at Meza to stop. Meza began to run and pulled out his gun.

At 1:57 am, ShotSpotter showed a fresh red dot on Foothill Boulevard. The shots recorded at that moment came rapidly, five staccato blasts in less than two seconds.

As the echoes faded, Meza ran east on Foothill and then north on 61st. Before reaching the end of the block, he slowed and then collapsed to the sidewalk. He died that night at Highland Hospital.

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