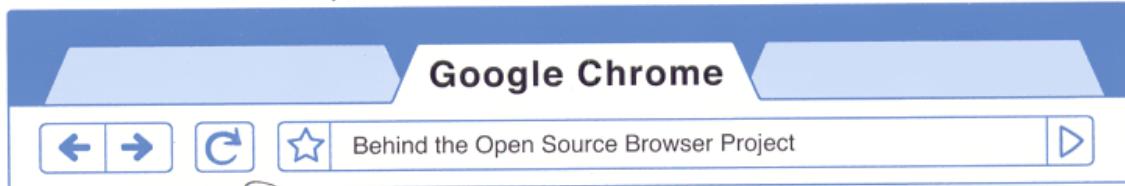


Google
on
Google Chrome

A comic book by Google,
drawn by Scott McCloud

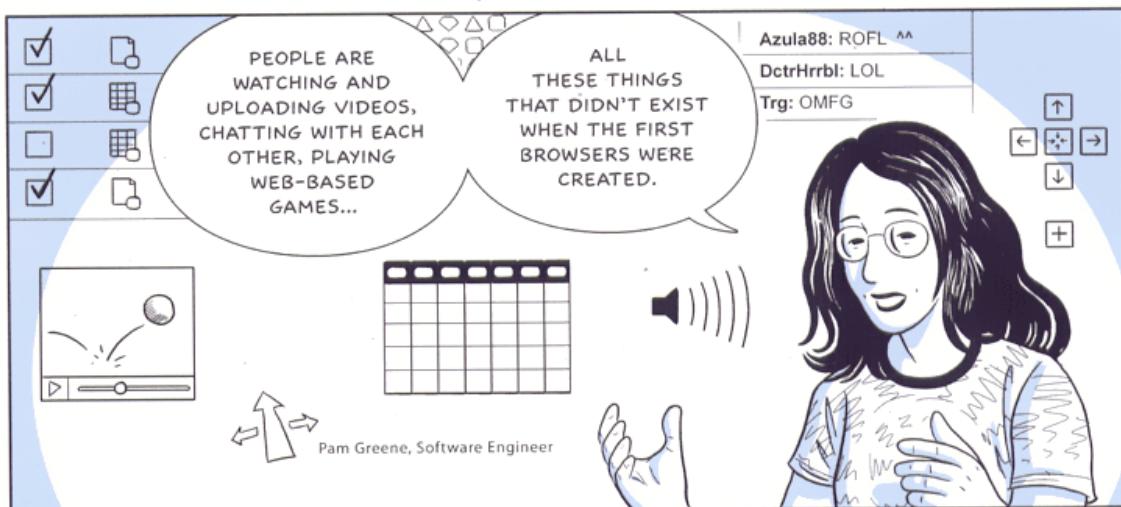
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to help ease bandwidth of the original site.

- [Brian](#)



TODAY, MOST OF WHAT WE USE THE WEB FOR ON A DAY-TO-DAY BASIS AREN'T JUST WEB PAGES, THEY'RE APPLICATIONS.

Brian Rakowski,
Product Manager



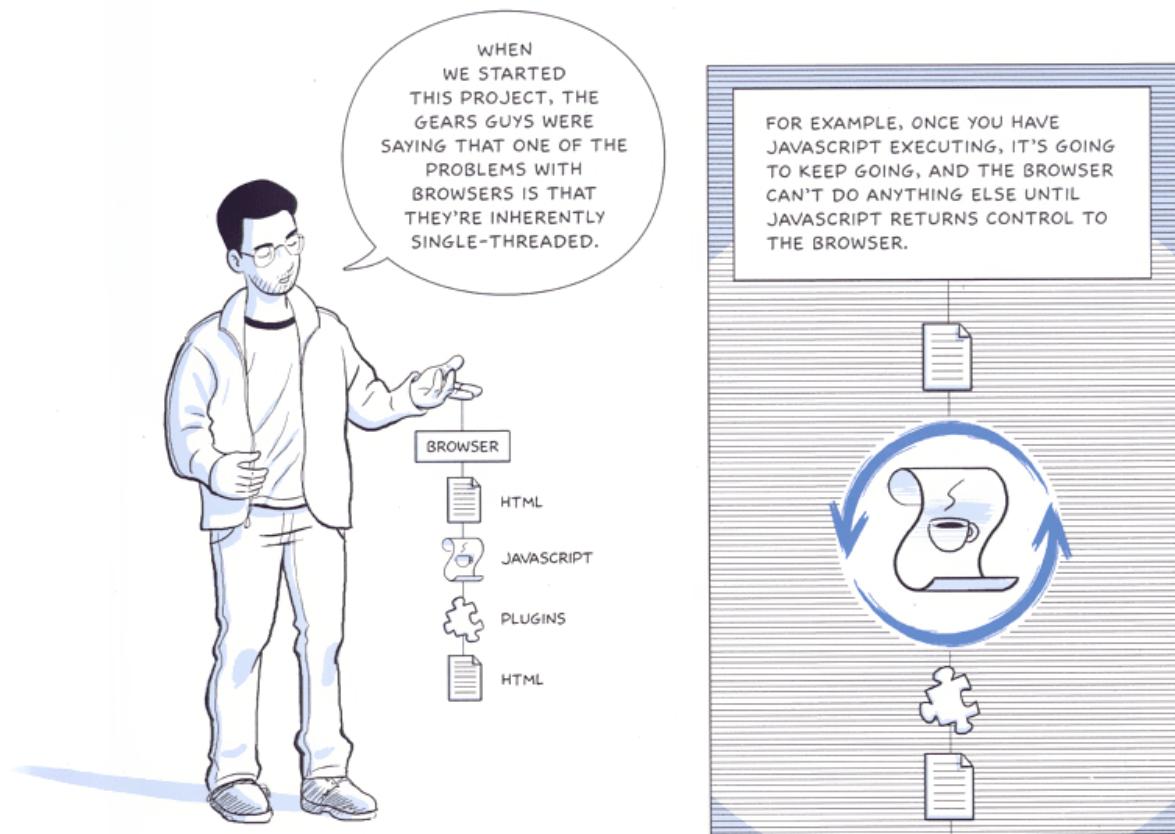
2008



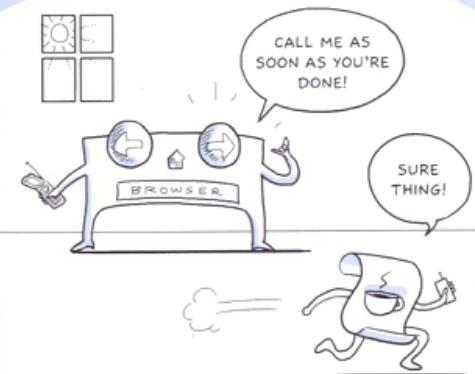
Part One



Stability, Testing and the Multi-Process Architecture

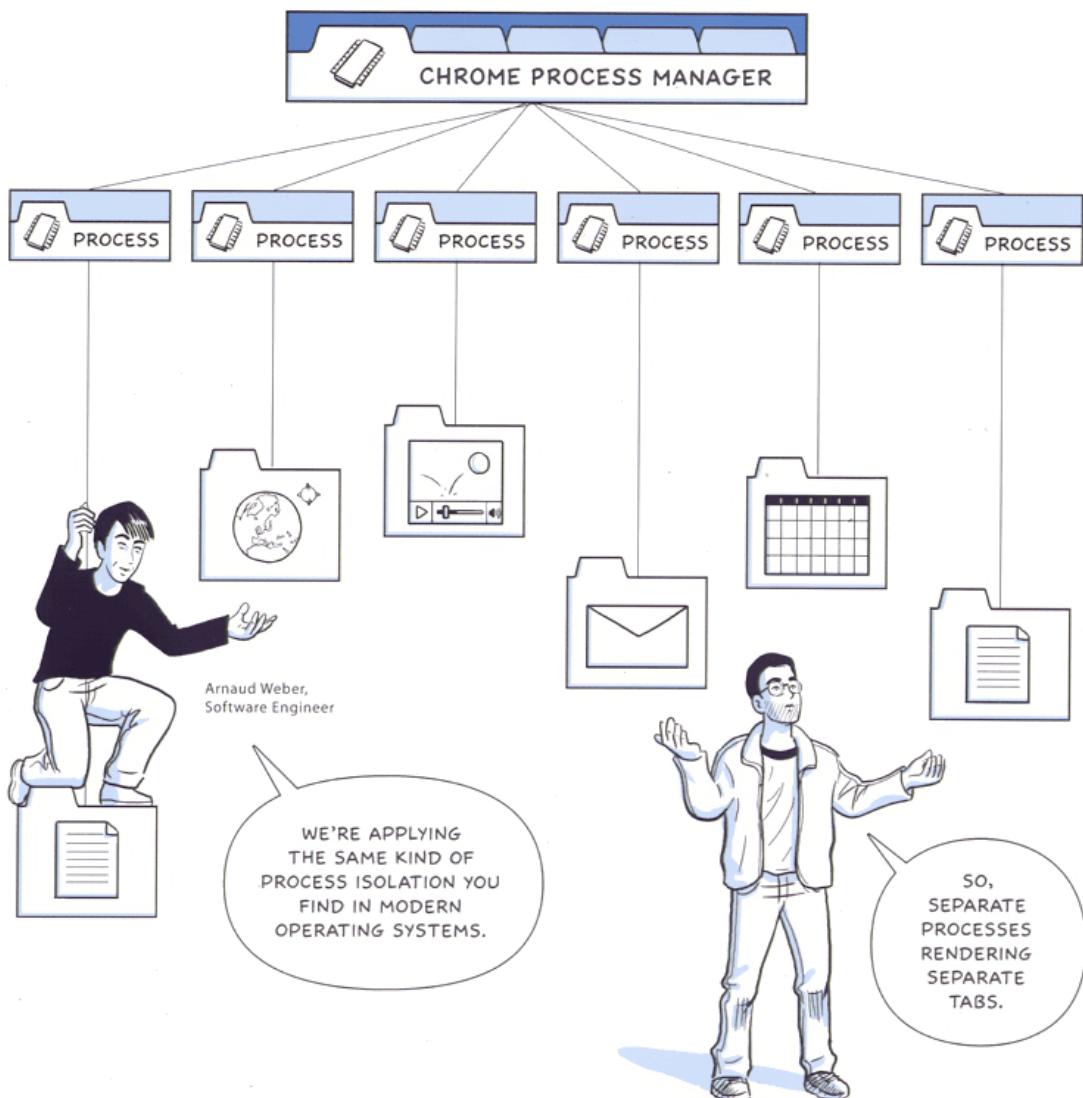
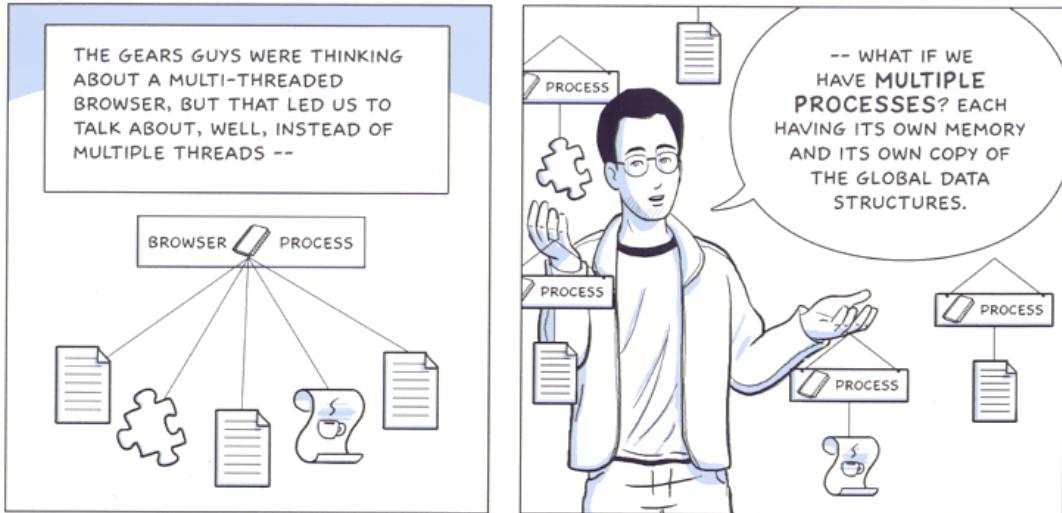


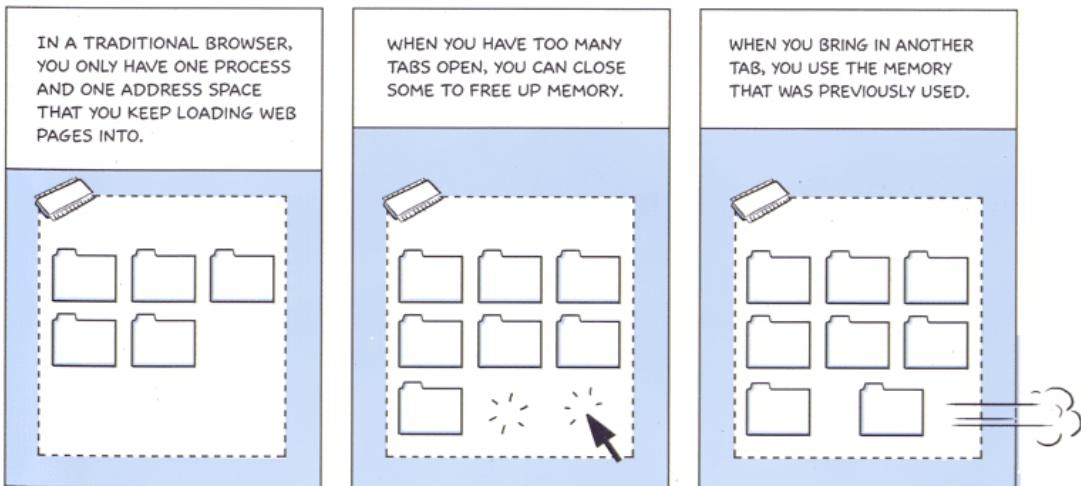
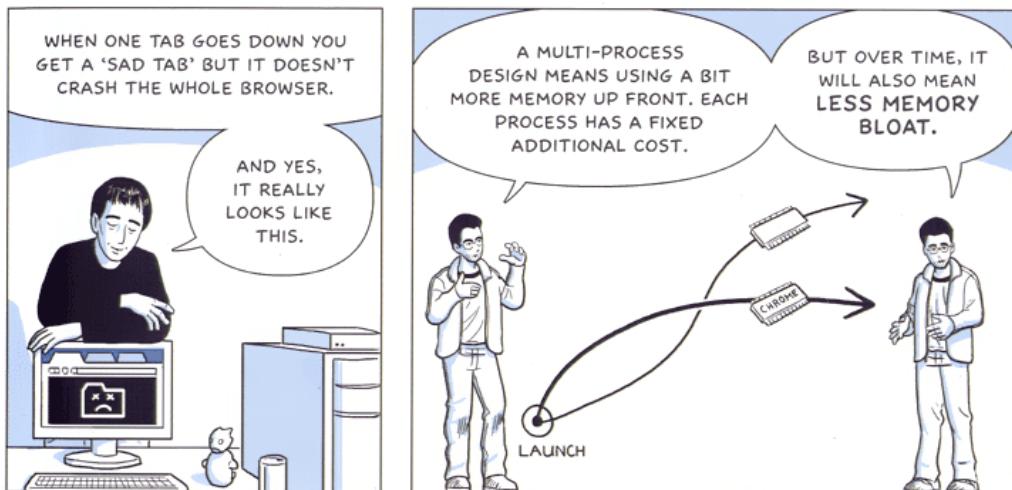
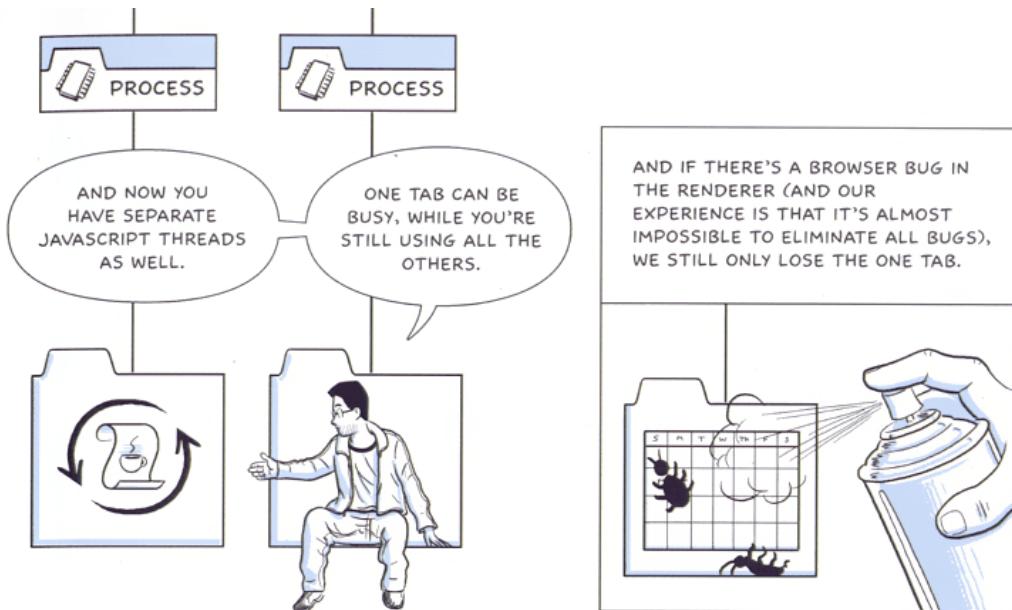
SO DEVELOPERS WRITE APIs THAT ARE ASYNCHRONOUS --



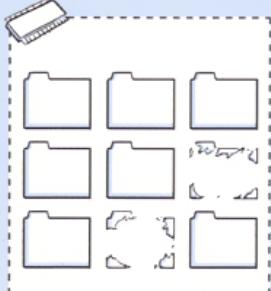
-- AND EVERY NOW AND THEN THE BROWSER LOCKS UP BECAUSE JAVASCRIPT IS HUNG UP ON SOMETHING.







BUT AS TIME GOES ON,
FRAGMENTATION RESULTS --
LITTLE BITS OF MEMORY
STILL GET USED EVEN WHEN
A TAB GETS CLOSED.

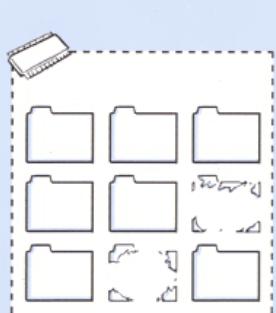
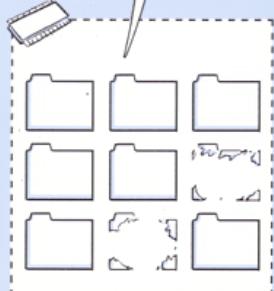


EITHER WE
HAVE MEMORY THAT
NOTHING CAN REFER TO
AGAIN, OR THERE'S A
PIECE OF DE-ALLOCATED
MEMORY WE STILL HAVE
POINTERS TO.



Mike Belche,
Software Engineer

SO WHEN THE
BROWSER WANTS TO
OPEN A NEW TAB, IT
CAN'T FIT IT IN THE
EXISTING SPACE --



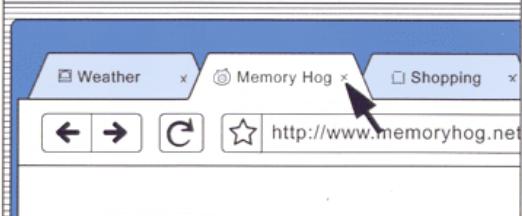
-- AND SO
THE OS HAS
TO GROW THE
BROWSER'S
ADDRESS
SPACE.

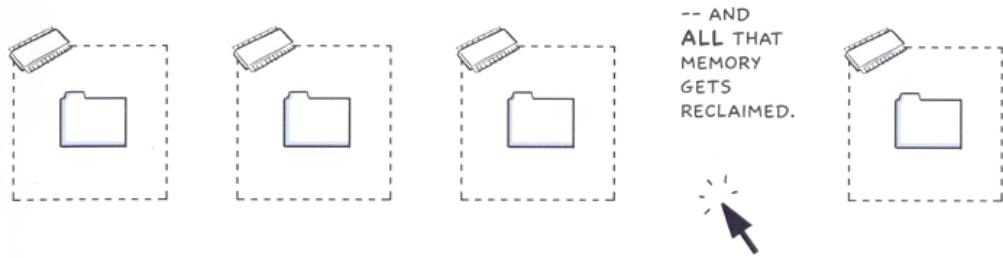


AND THIS PROBLEM GROWS ALL DAY, AS
THE LIFETIME OF THE BROWSER EXTENDS.



BUT WHEN A TAB IS CLOSED IN GOOGLE
CHROME, YOU'RE ENDING THE WHOLE PROCESS --





OPEN A NEW TAB NOW, AND YOU'RE STARTING FROM SCRATCH.

SO AS YOU BROWSE, WE'RE CREATING AND DESTROYING PROCESSES ALL THE TIME. IF THERE'S A CRAZY MEMORY LEAK IT WON'T AFFECT YOU FOR THAT LONG BECAUSE YOU'LL PROBABLY CLOSE THE TAB AT SOME POINT AND GET THAT MEMORY BACK.

Brett Wilson, Software Engineer

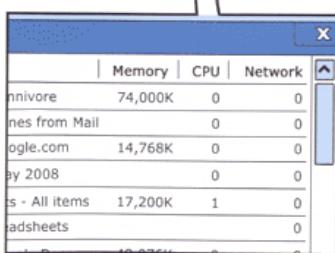
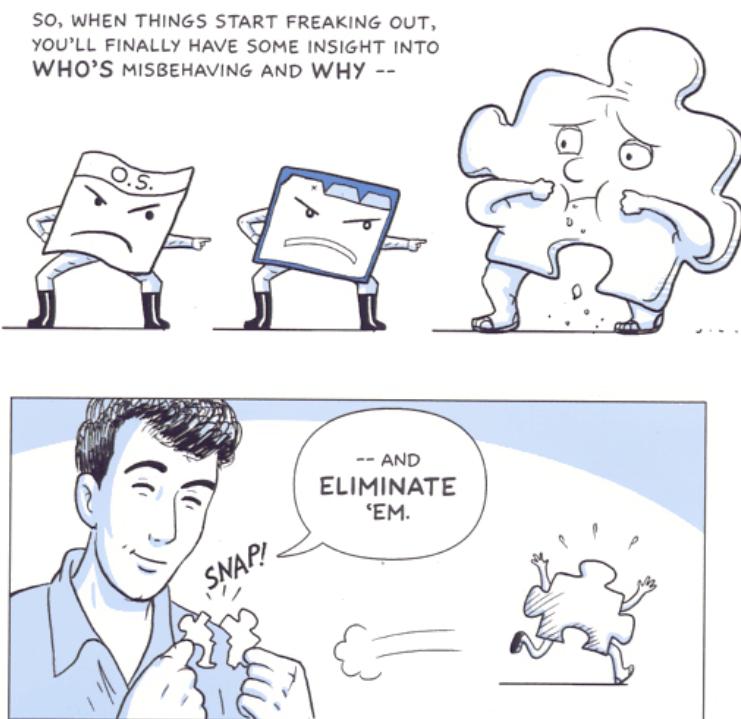
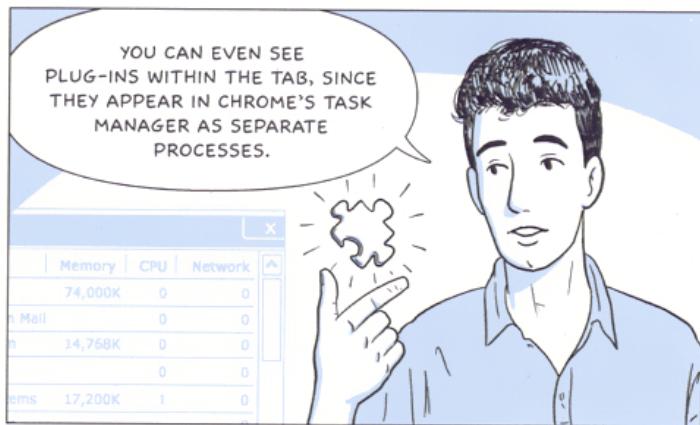
This panel features a man in a blue polo shirt gesturing with his hands while speaking. Behind him are several computer monitors, each displaying a different application window like a mail icon or a search bar. The background is a textured wall.

AND WE'RE TAKING IT ONE STEP FURTHER. SUPPOSE YOU NAVIGATE FROM DOMAIN A TO DOMAIN B. THERE'S NO NEED FOR ANY RELATIONSHIP BETWEEN THE TWO SITES --

-- SO NOW WE CAN THROW AWAY THE OLD RENDERING ENGINE, THE OLD DATA STRUCTURES, THE OLD PROCESS.

SO, EVEN WITHIN A TAB, WE CAN BE COLLECTING AND TOSSED OUT THE GARBAGE, RECYCLING THE WHOLE PROCESS.

The left side of this panel shows a man walking from a large letter 'A' to a large letter 'B'. Above him is a speech bubble with the text. The right side shows a trash can with a piece of paper labeled 'Site A' being thrown into it, with a pencil nearby.





WITHIN 20-30 MINUTES OF EACH NEW BROWSER BUILD, WE CAN TEST IT ON TENS OF THOUSANDS OF DIFFERENT WEB PAGES.

EACH WEEK, "CHROME BOT" TESTS MILLIONS OF PAGES, GIVING OUR DEVELOPERS EARLY RESULTS THEY'D OTHERWISE HAVE TO WAIT UNTIL EXTERNAL BETA FOR.

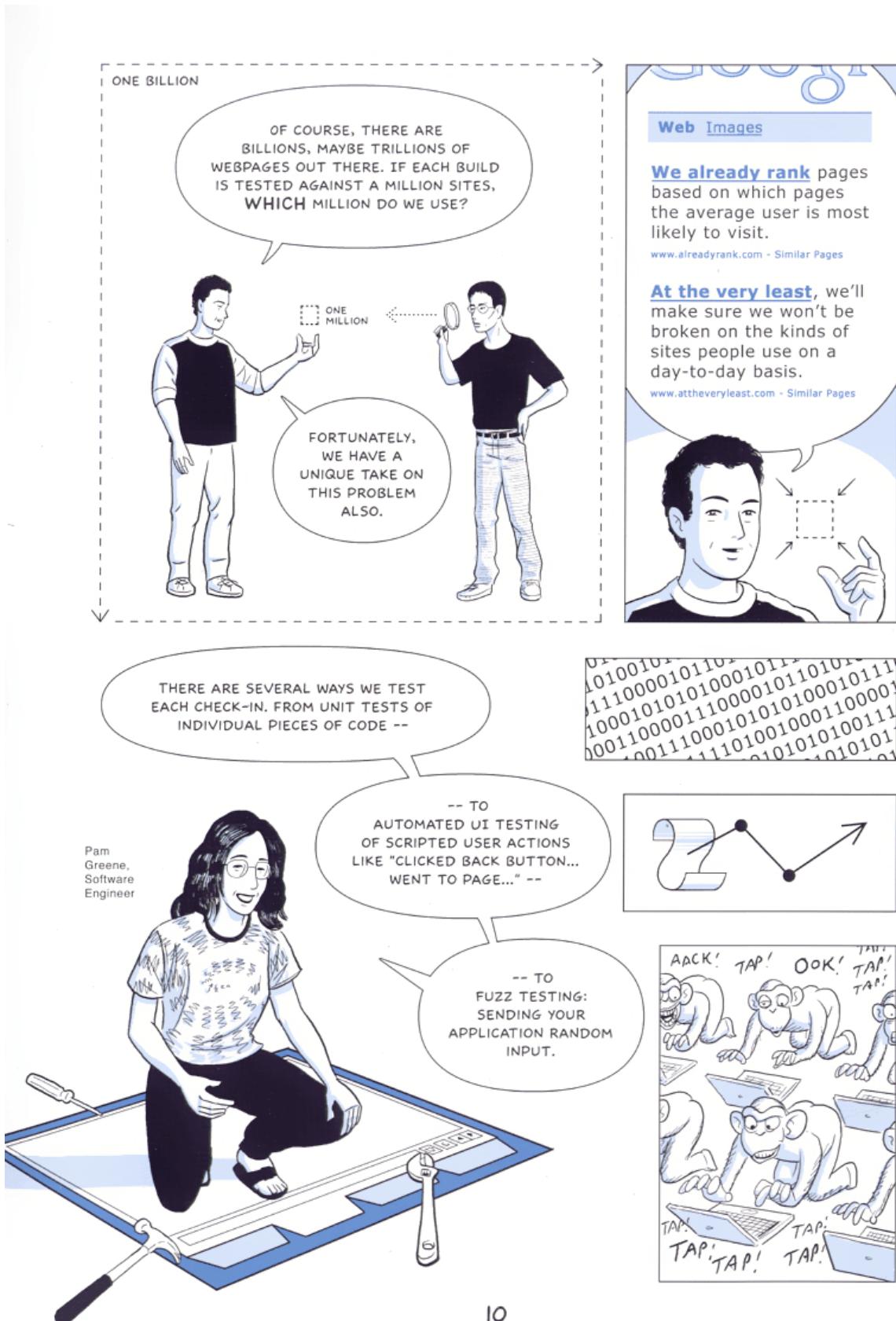
THE KEY IS CATCHING PROBLEMS AS EARLY AS POSSIBLE. IT IS LESS EXPENSIVE AND EASIER TO FIX THEM RIGHT AWAY. AFTER A FEW DAYS IT IS HARDER TO TRACK THEM DOWN.

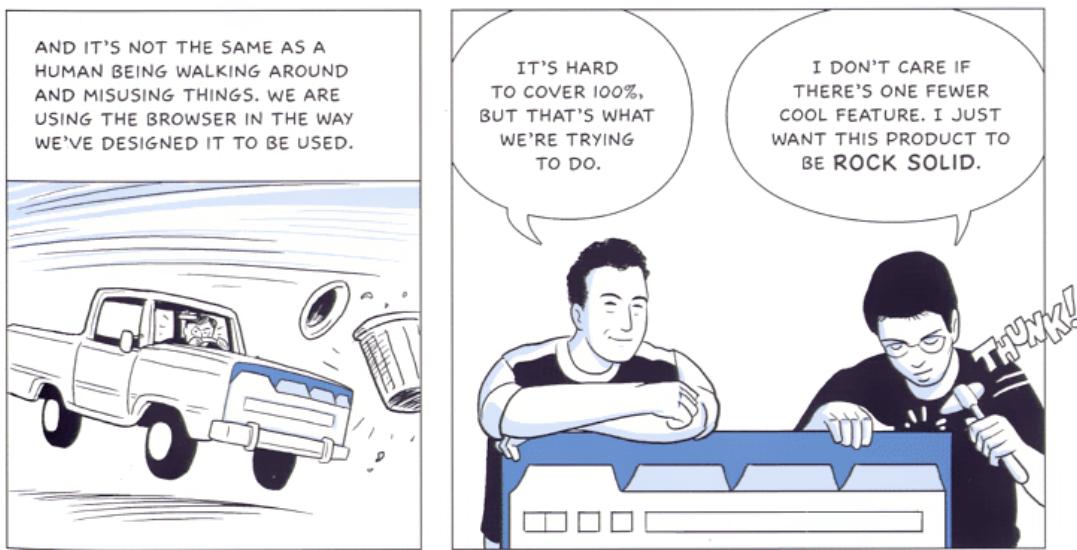
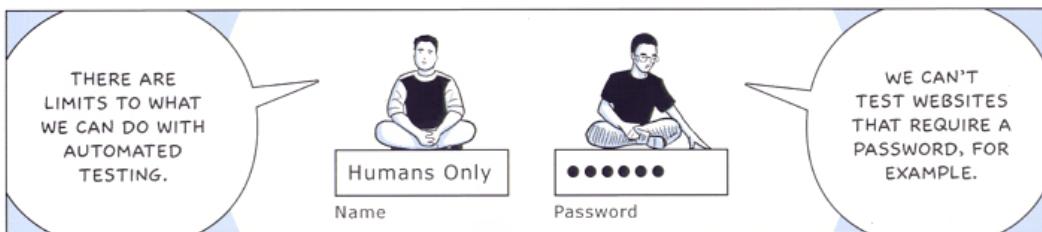
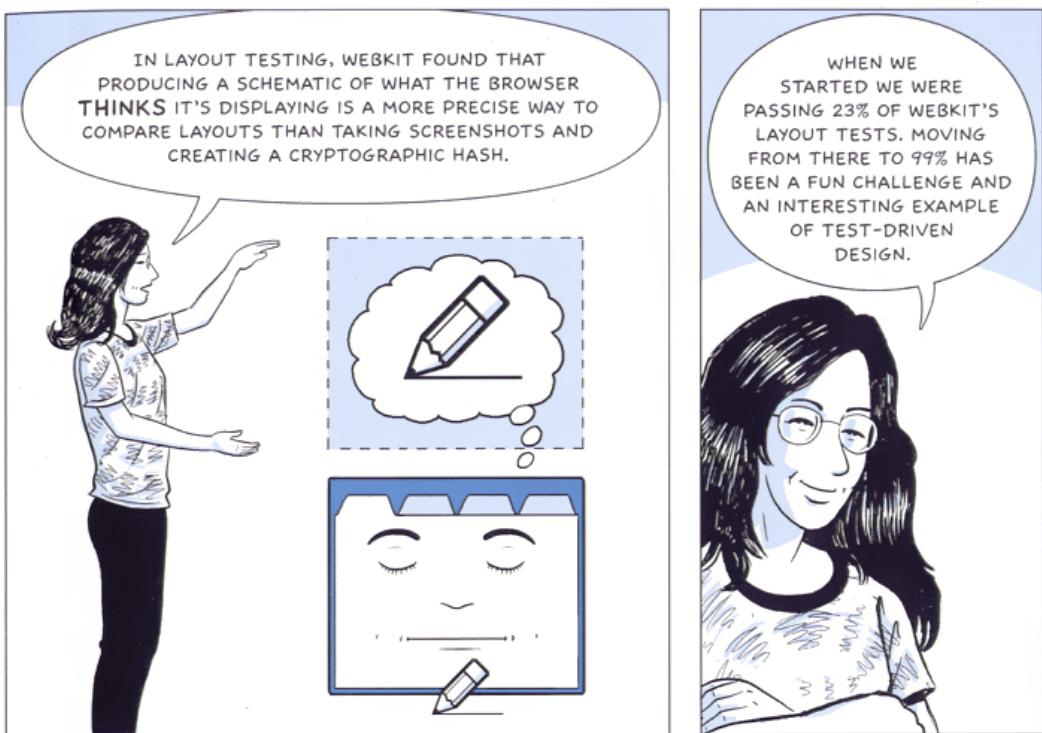


AND CATCHING THEM EARLY HELPS ENGINEERS WRITE BETTER CODE. THEY SAY, "OH, THIS MISTAKE IS PART OF A PATTERN" AND THE NEXT TIME, THEY'RE LESS LIKELY TO MAKE IT.



Erik Kay, Software Engineer

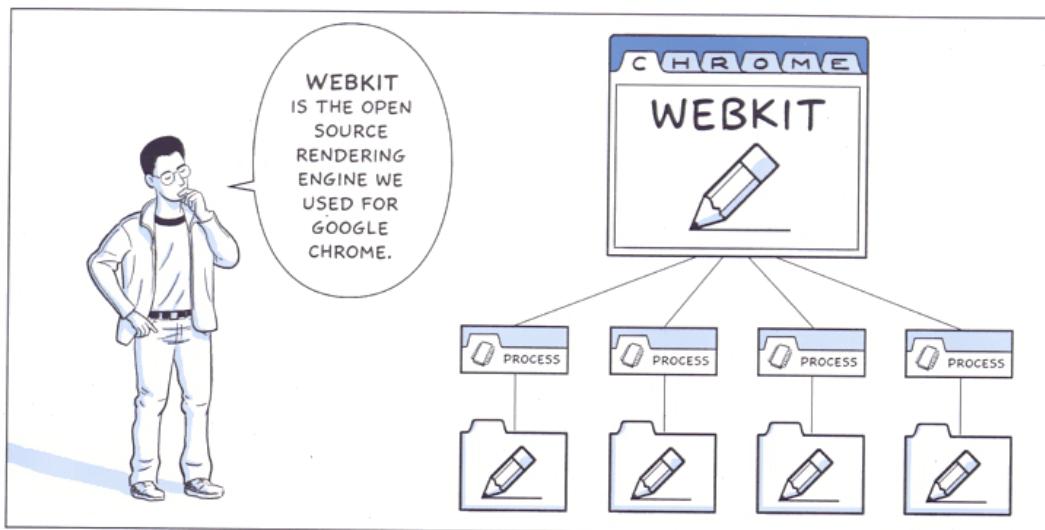




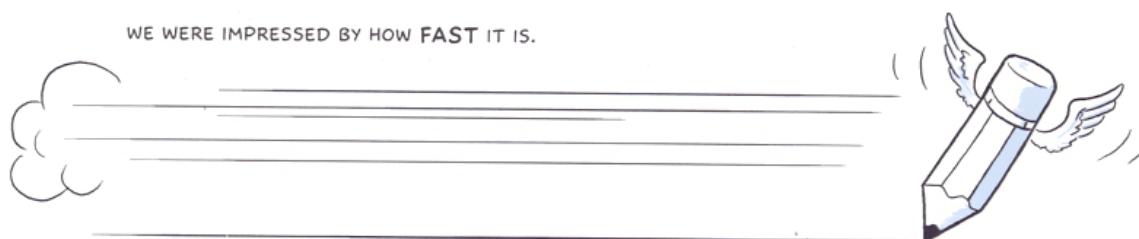
Part Two

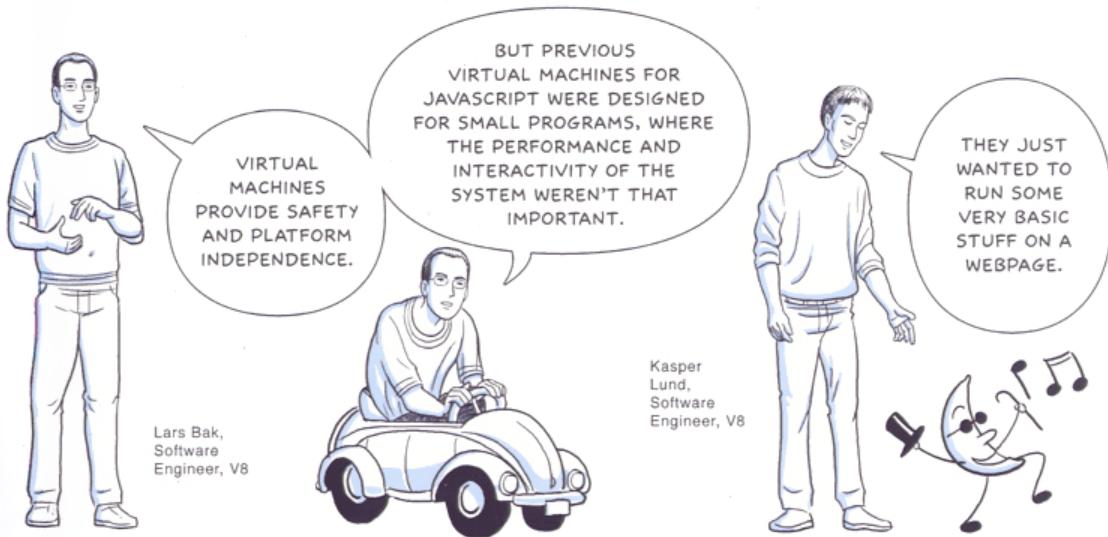
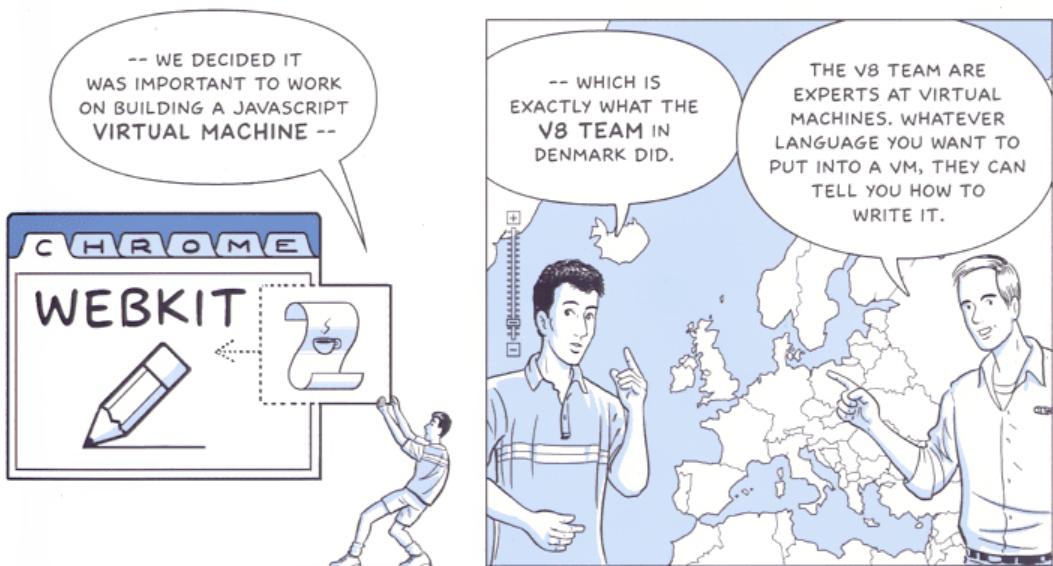
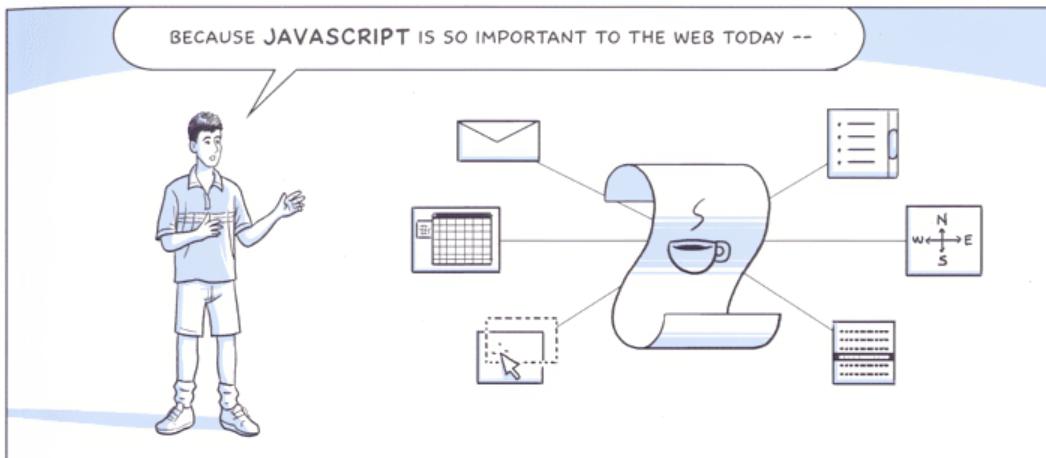


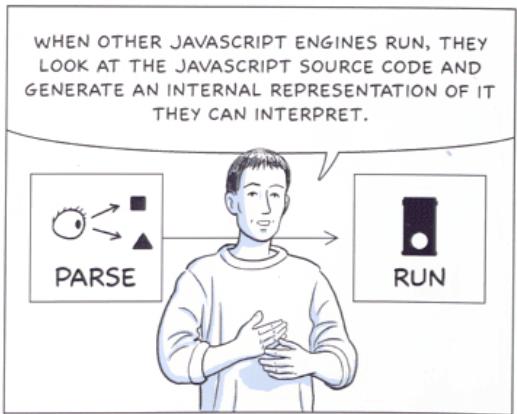
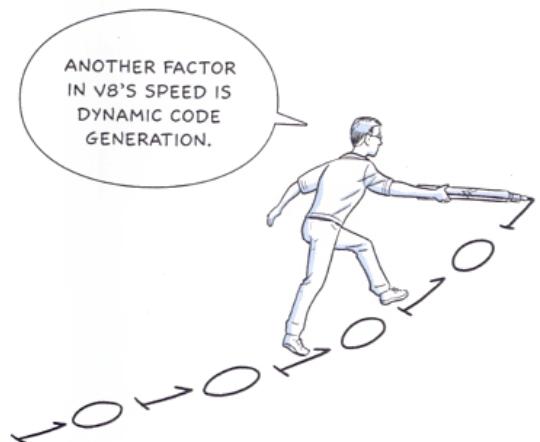
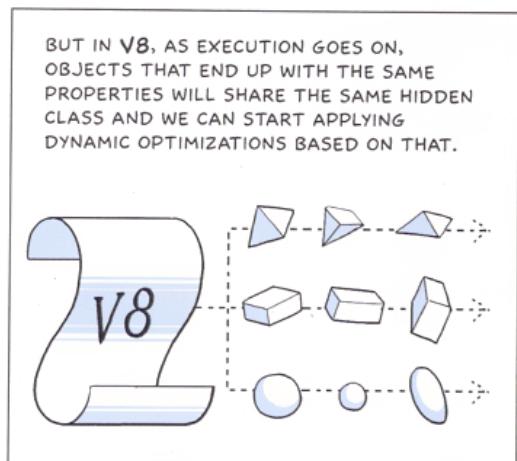
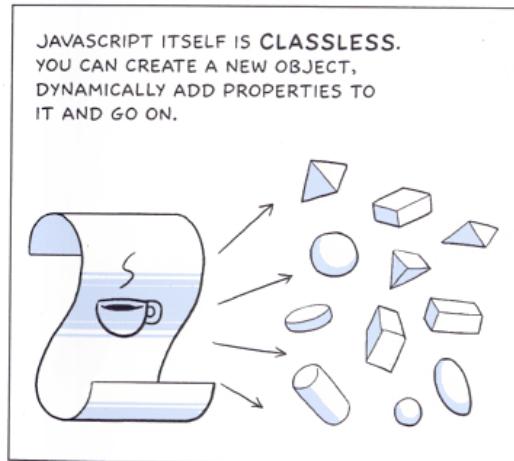
Speed: WebKit and V8



WE WERE IMPRESSED BY HOW FAST IT IS.









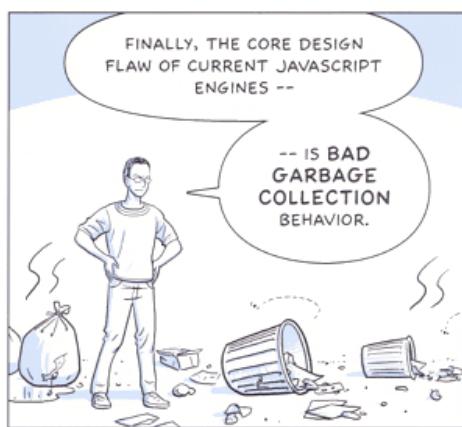
SO INSTEAD, V8 LOOKS AT THE JAVASCRIPT SOURCE CODE AND GENERATES MACHINE CODE THAT CAN RUN DIRECTLY ON THE CPU THAT'S RUNNING THE BROWSER.



- WHEN YOU INTERPRET ONCE AND COMPILE MACHINE CODE, THEN
- THAT CODE IS YOUR REPRESENTATION OF THE JAVASCRIPT SOURCE
- CODE AND IT DOESN'T NEED TO BE INTERPRETED, IT JUST RUNS.

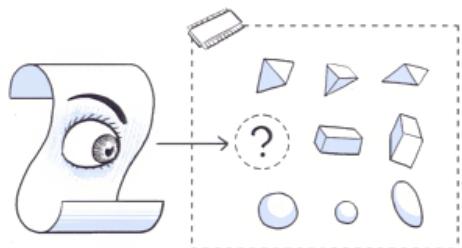


1010100010100010101010010101010000010101010000010101

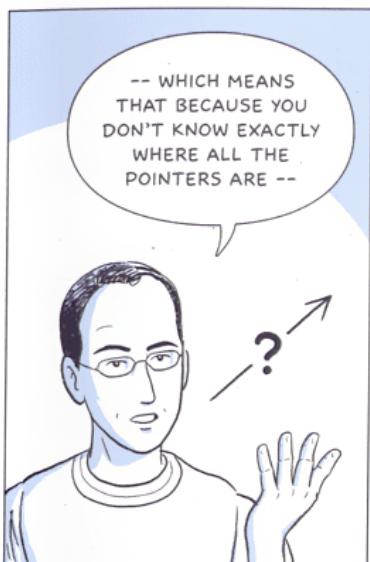


JAVASCRIPT AND OTHER MODERN OBJECT-ORIENTED PROGRAMMING LANGUAGES HAVE AUTOMATIC MEMORY MANAGEMENT.

IF YOU DON'T HAVE A REFERENCE TO AN OBJECT ANYMORE, ITS MEMORY CAN BE RECLAIMED BY THE SYSTEM. THAT'S GARBAGE COLLECTION, AND IT'S A FAIRLY TRIVIAL PROCESS.

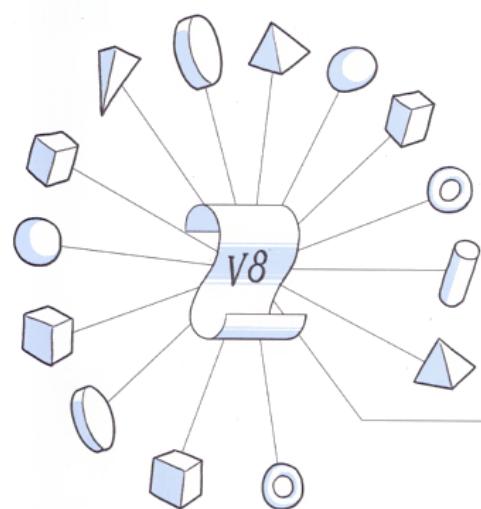


BUT
IN EXISTING
JAVASCRIPT
VIRTUAL MACHINES,
THEY USE
CONSERVATIVE
GARBAGE
COLLECTION --



-- YOU START SEARCHING THROUGH THE EXECUTION STACK TO SEE WHICH WORDS LOOK LIKE POINTERS.

BUT THE ONES THAT SORT OF LOOK LIKE POINTERS COULD ALSO BE INTEGERS THAT JUST HAPPEN TO HAVE THE SAME ADDRESS AS AN OBJECT IN THE OBJECT HEAP.

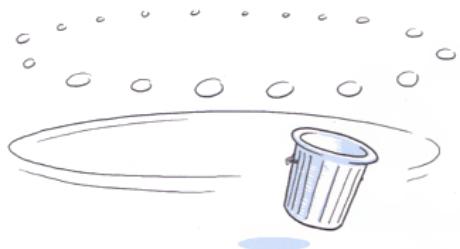


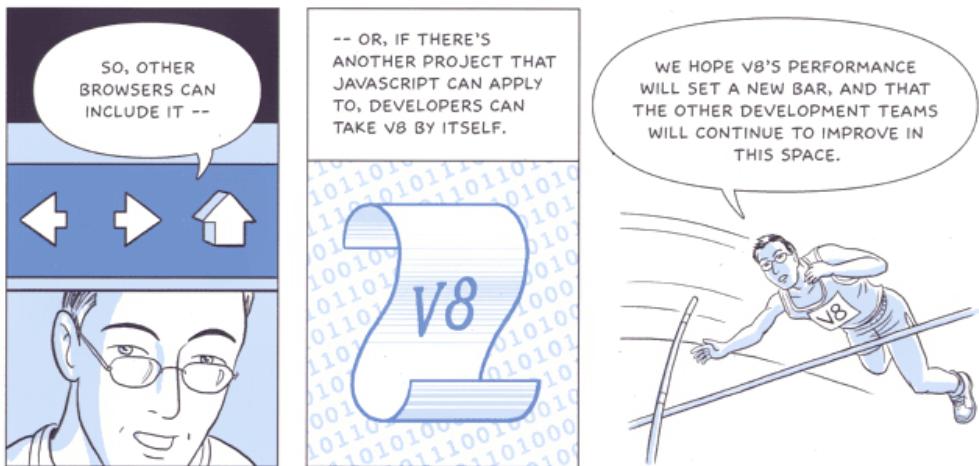
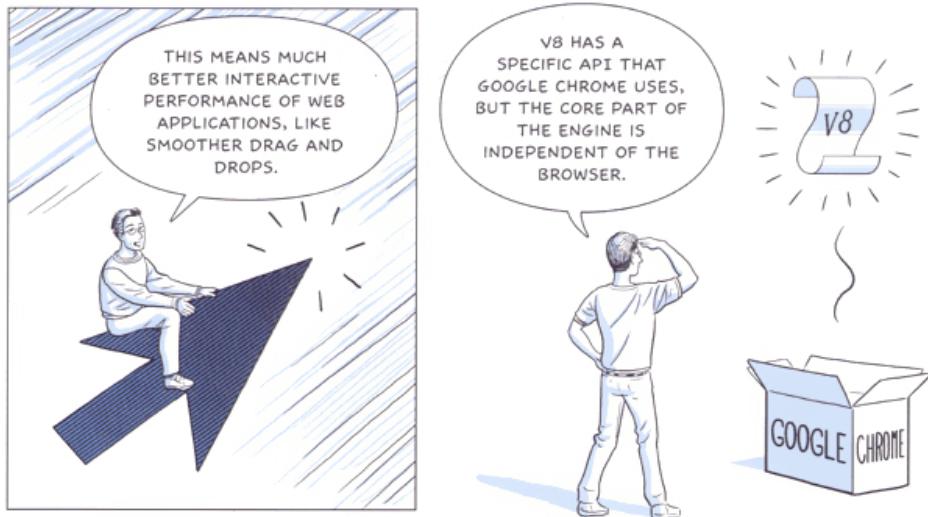
IN V8, WE ARE USING **PRECISE** GARBAGE COLLECTION, SO WE KNOW PRECISELY WHERE ALL OF THE POINTERS ARE ON THE STACK AND THIS GIVES US SEVERAL ADVANTAGES.

ONE IS THAT WE CAN MIGRATE AN OBJECT TO ANOTHER PLACE AND JUST REWIRE THE POINTER.



MEANING QUICK GARBAGE COLLECTION ROUND-TRIPS THAT ARE CLOSE TO A FEW MILLISECONDS, COMPARED TO PROCESSING ALL 100MB OF DATA WHICH COULD CAUSE SECOND-LONG PAUSES.

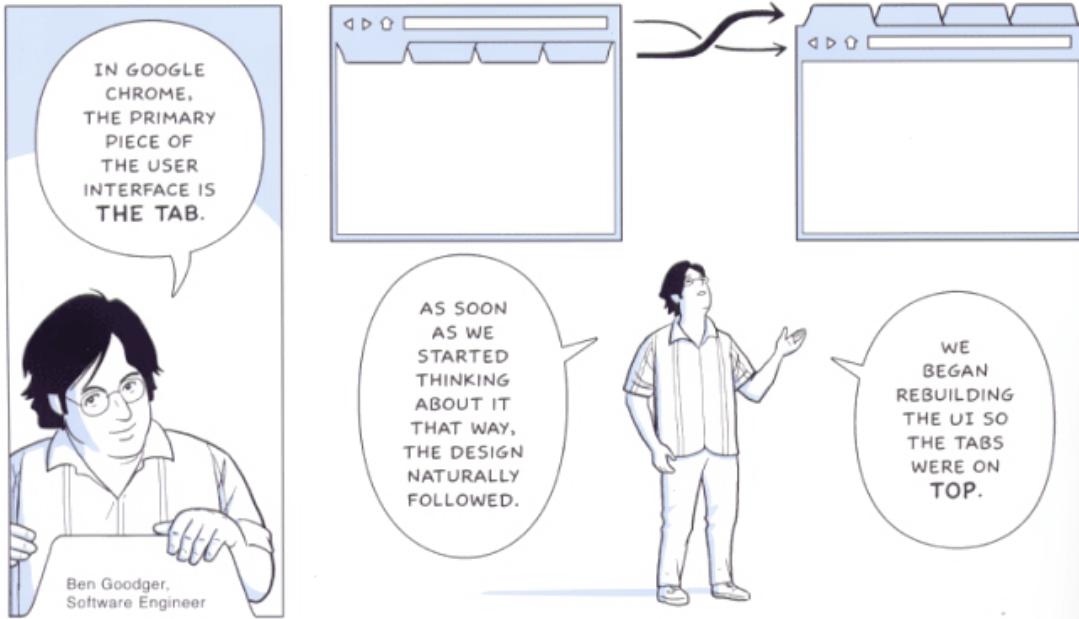




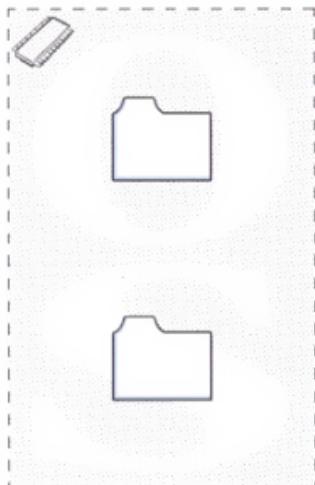
Part Three

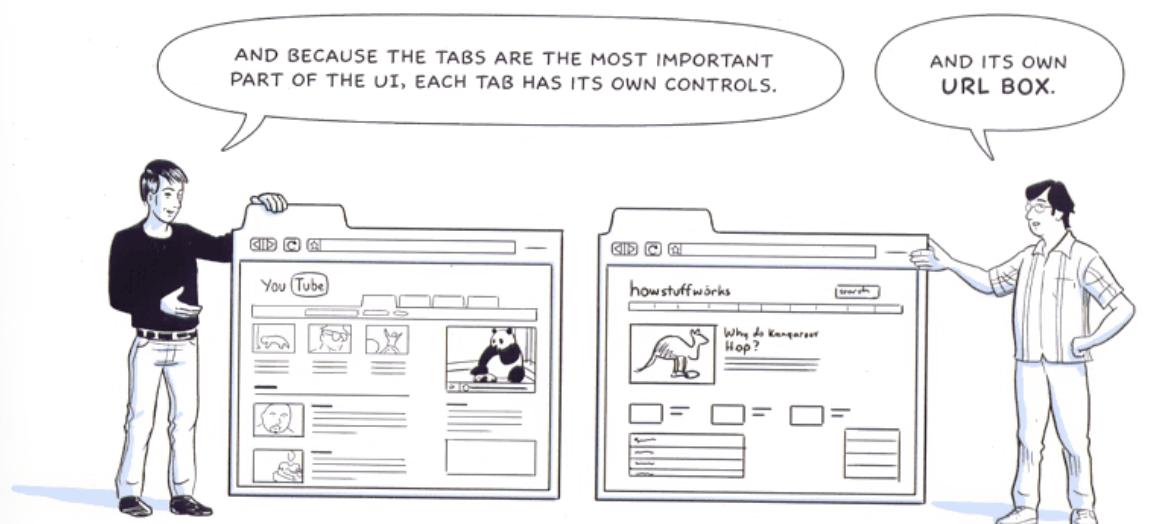


Search and the User Experience



WE COULD DETACH THE TABS EASILY BECAUSE OF THE SEPARATION OF THE BROWSER AND TAB PROCESSES.





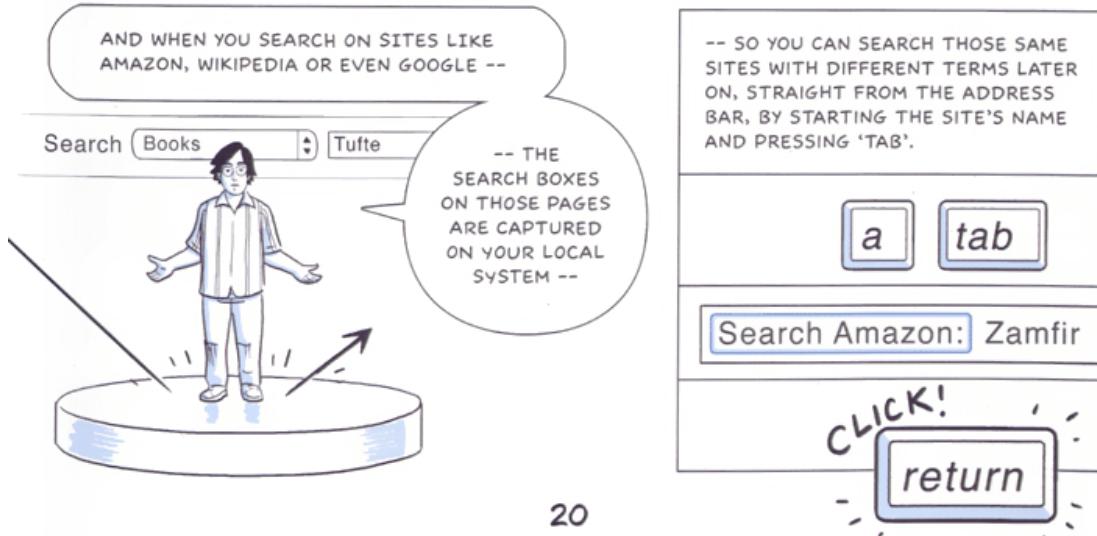
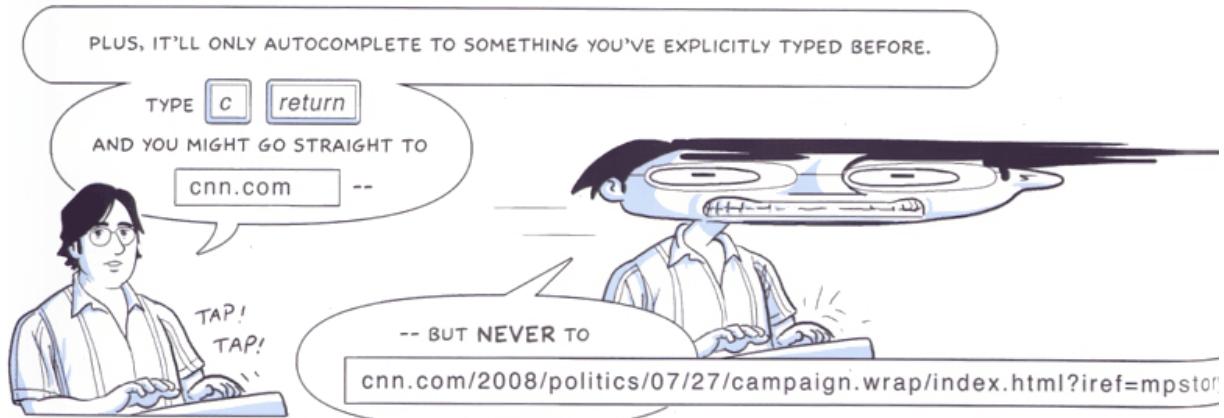
THE OMNIBOX HANDLES FAR MORE THAN JUST URLs.

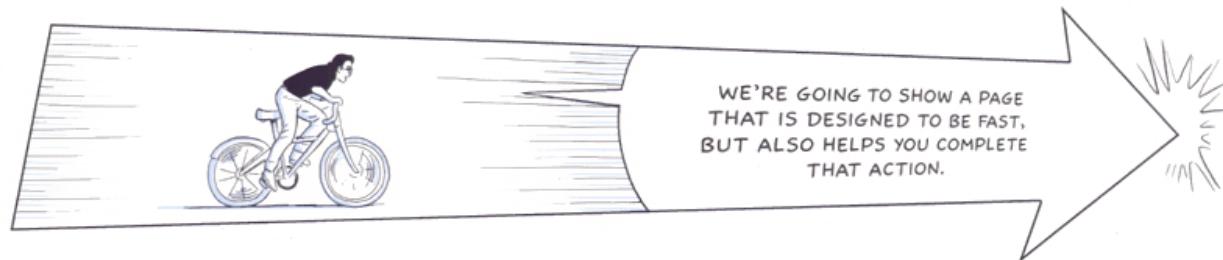
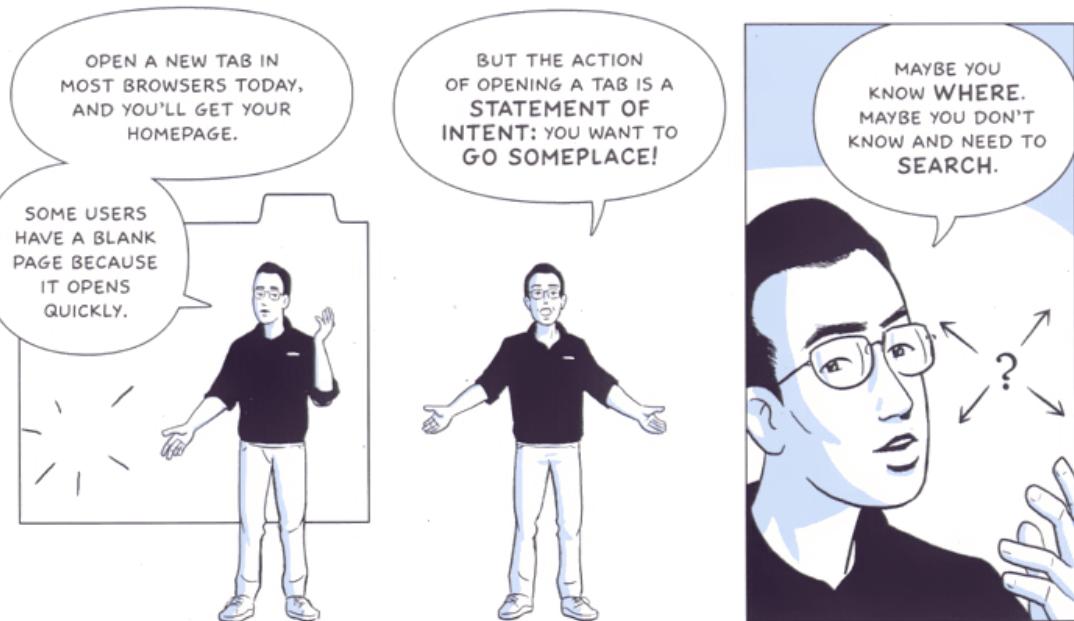
IT ALSO OFFERS SUGGESTIONS FOR SEARCHES, TOP PAGES YOU'VE VISITED BEFORE, PAGES YOU HAVEN'T VISITED BUT ARE POPULAR AND MORE...

YOU HAVE FULL TEXT SEARCH OVER YOUR HISTORY. IF YOU FOUND A GOOD SITE FOR DIGITAL CAMERAS YESTERDAY, YOU DON'T HAVE TO BOOKMARK THAT PAGE.

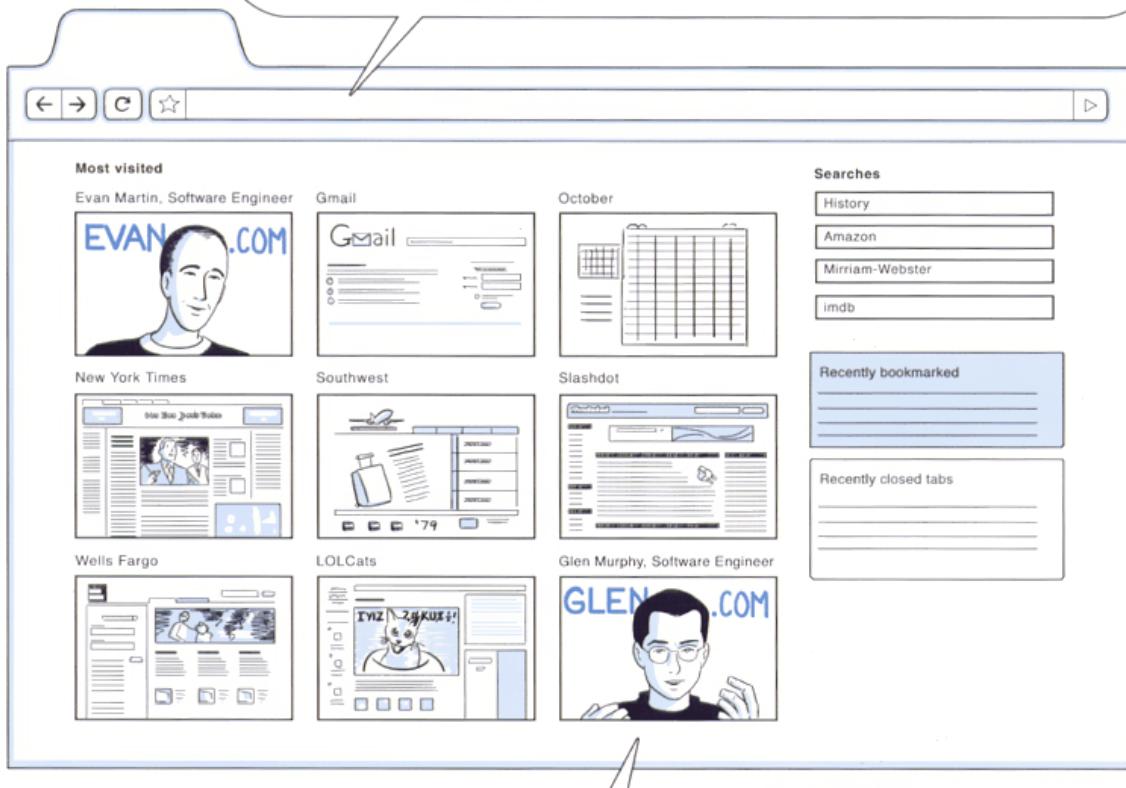
JUST TYPE 'DIGITAL CAMERA' AND QUICKLY GET BACK TO IT.

Glen Murphy,
Software Engineer



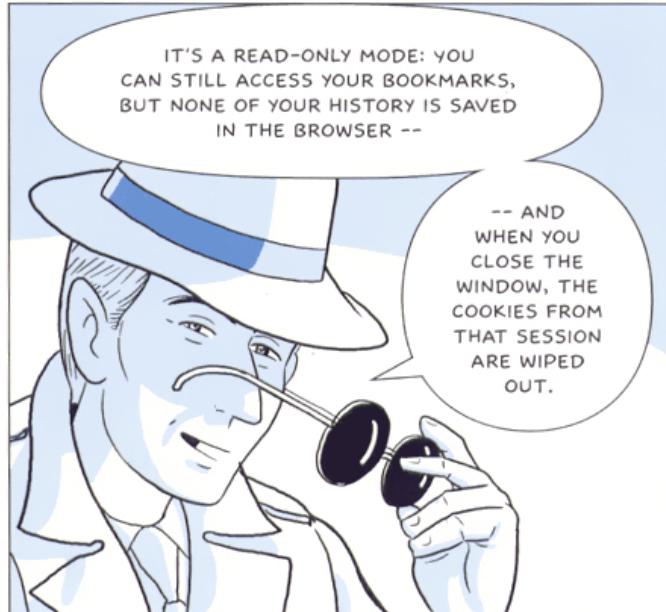


IT'S THE PAGES YOU WERE GOING TO TYPE INTO THE URL BOX ANYWAY.
GOOGLE CHROME USES YOUR BEHAVIOR IN THE OMNIBOX TO FEED INTO THAT PAGE.

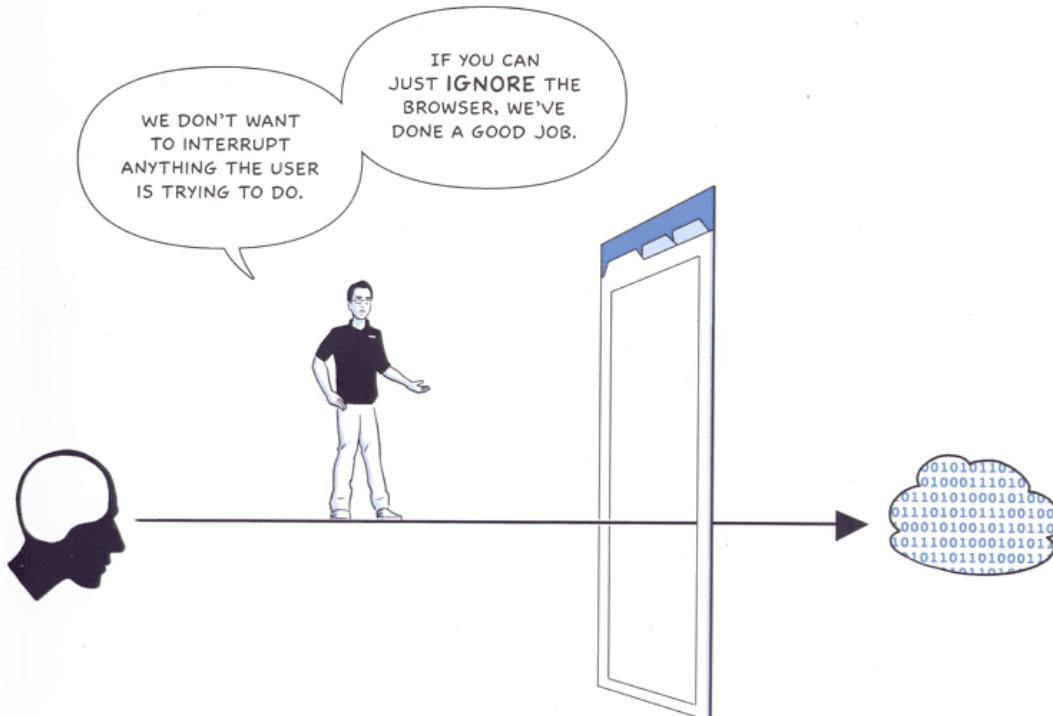
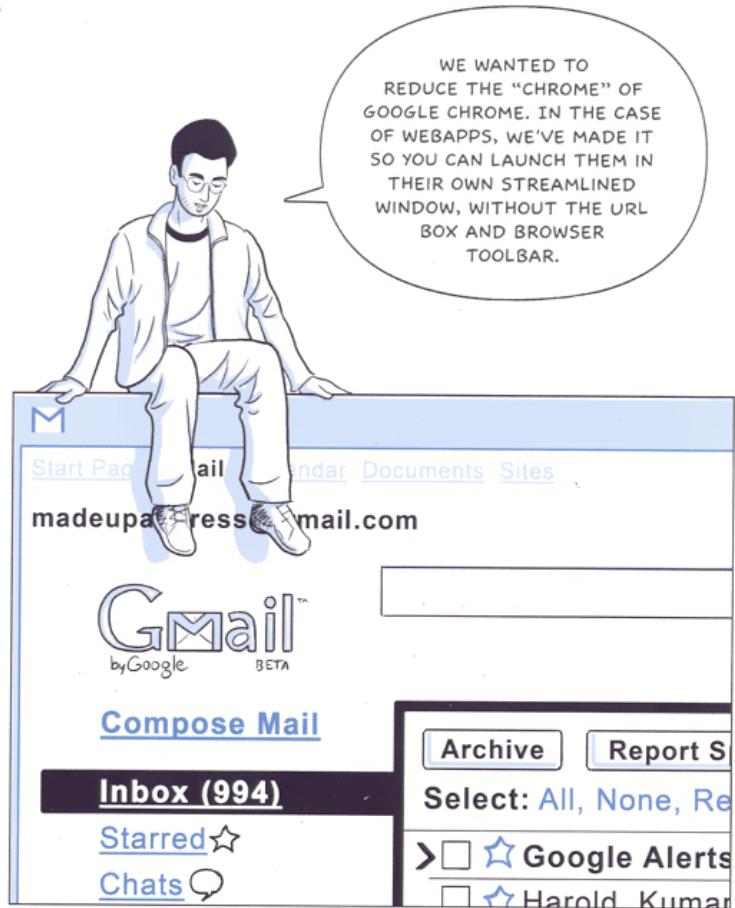
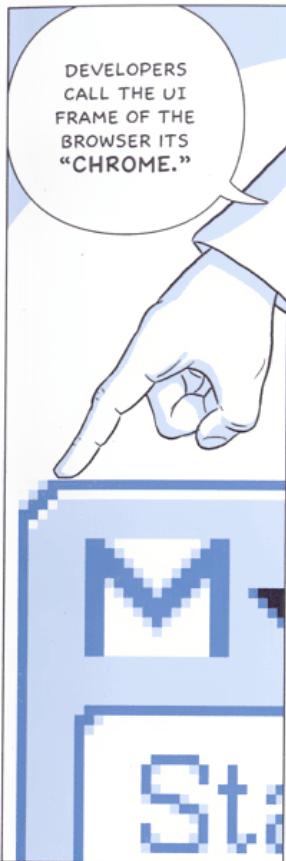


YOU MIGHT OPEN IT AND BE, LIKE, WHAT'S ALL MY STUFF DOING HERE? BUT
AFTER A WHILE, YOU SEE THIS PAGE AND IT'S JUST YOU, IT'S YOUR BROWSER.

GOOGLE CHROME HAS A PRIVACY
MODE. YOU CAN CREATE AN
'INCOGNITO' WINDOW AND NOTHING
THAT OCCURS IN THAT WINDOW IS
EVER LOGGED ON YOUR COMPUTER.







Part Four

← → ⌂ ⭐ Security, Sandboxing and Safe Browsing ▶



MALWARE AND PHISHING ARE A HUGE PROBLEM FOR USERS, AFFECTING TRUST AND CONFIDENCE IN THE WEB.

WHEN WE STARTED THIS PROJECT, IT WAS A VERY DIFFERENT LANDSCAPE FROM WHEN THE OTHER BROWSERS STARTED.

BACK THEN, IT WAS ABOUT RENDERING THE PAGE AND GETTING THE COOL THINGS WORKING. THERE WAS NO MONETARY INCENTIVE TO PUT MALWARE ON USERS' MACHINES.



NOW, MALWARE IS VERY FINANCIALLY DRIVEN. IT'S ALL ABOUT STEALING PASSWORDS AND MOVING MONEY AROUND.



IN THINKING ABOUT SECURITY, WE BEGAN WITH THE ASSUMPTION THAT YOUR BROWSER WOULD GET COMPROMISED.

YOU WILL EVENTUALLY ENCOUNTER MALWARE.

"Half-Empty"

Carlos Pizano,
Software Engineer

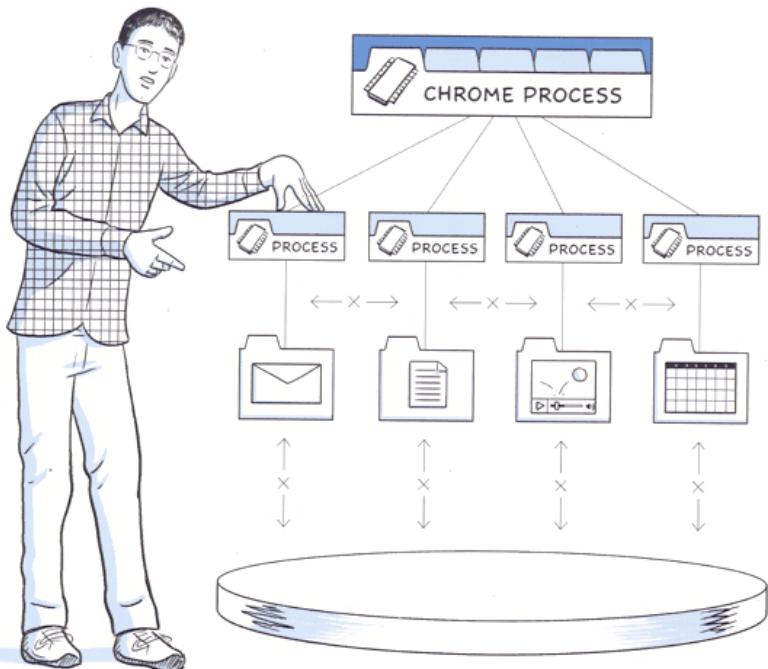
Ian Fette,
Product Manager

John Abd-El-Malek,
Software Engineer

WITH SANDBOXING, OUR GOAL IS TO PREVENT MALWARE FROM INSTALLING ITSELF ON YOUR COMPUTER OR USING WHAT HAPPENS IN ONE TAB TO AFFECT WHAT HAPPENS IN ANOTHER.

SO, FOR EACH OF THESE PROCESSES WE'VE STRIPPED AWAY ALL OF THEIR RIGHTS.

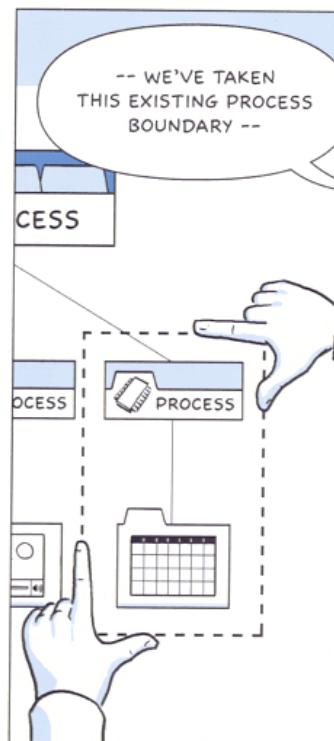
THEY CAN COMPUTE BUT THEY CAN'T WRITE FILES TO YOUR HARD DRIVE OR READ FILES FROM SENSITIVE AREAS LIKE YOUR DOCUMENTS OR DESKTOP.

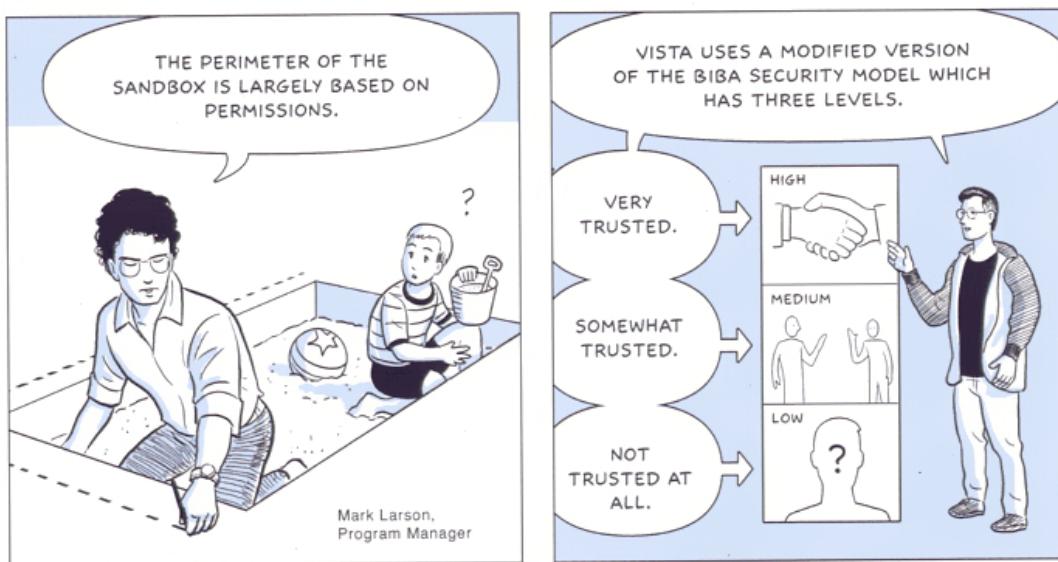
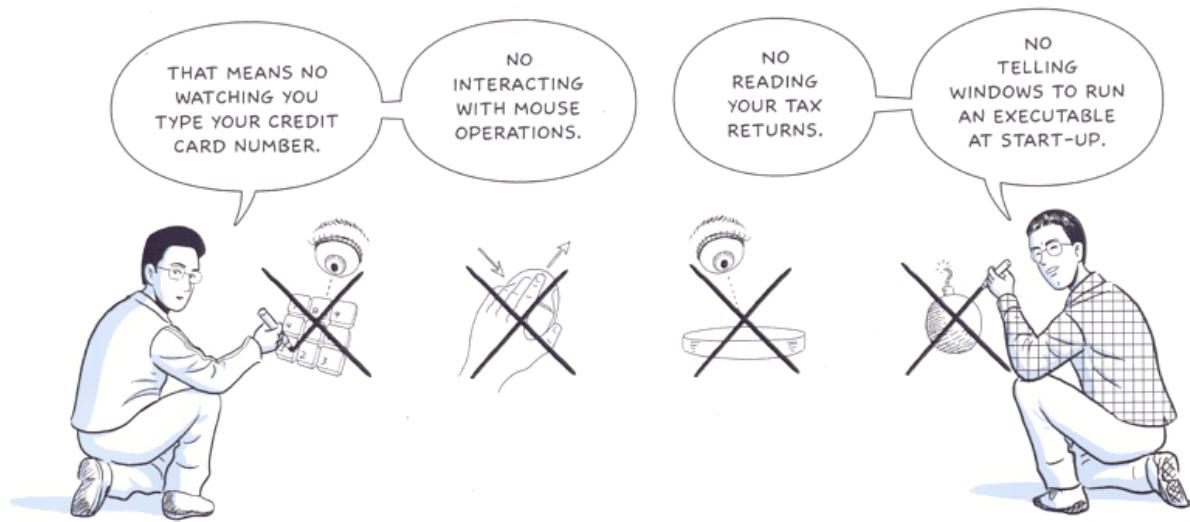


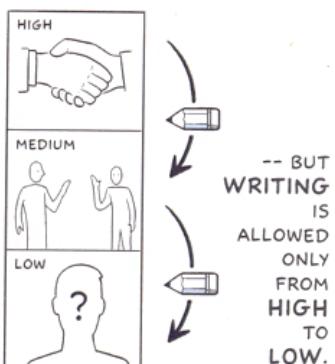
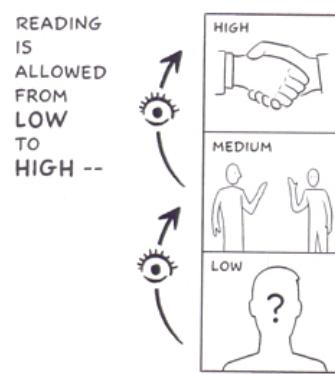
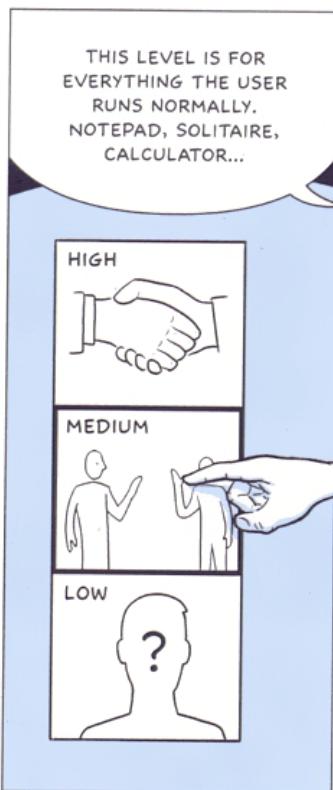
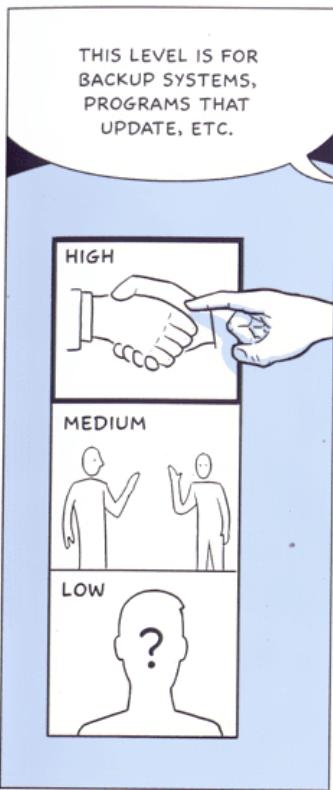
OR AS THE SANDBOX TEAM PUT IT --

-- WE'VE TAKEN THIS EXISTING PROCESS BOUNDARY --

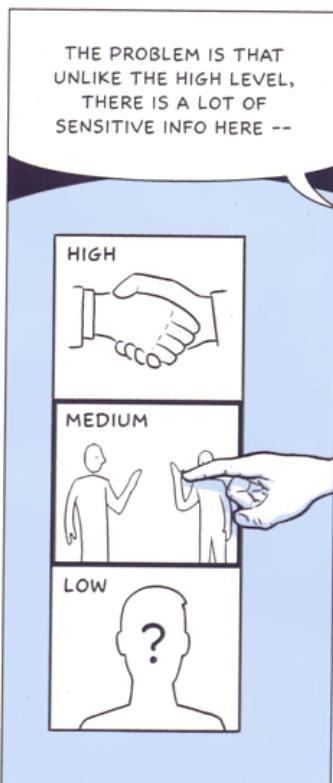
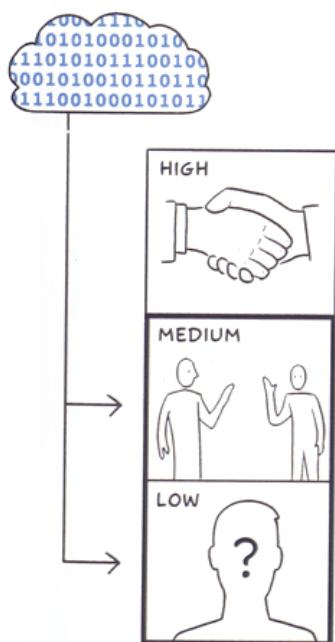
-- AND MADE IT INTO A JAIL.

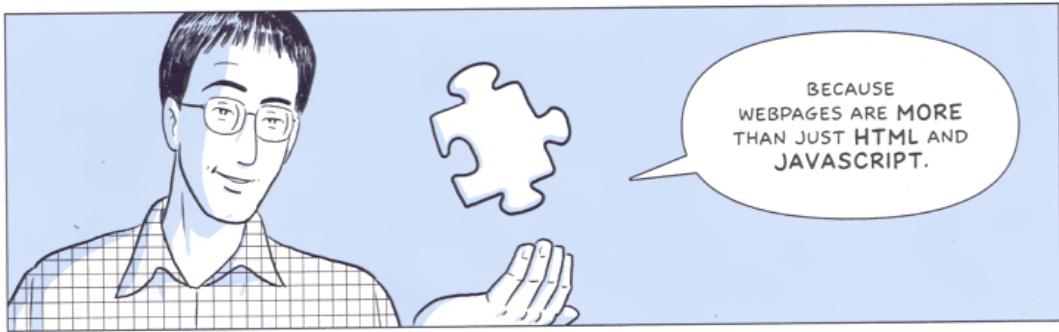
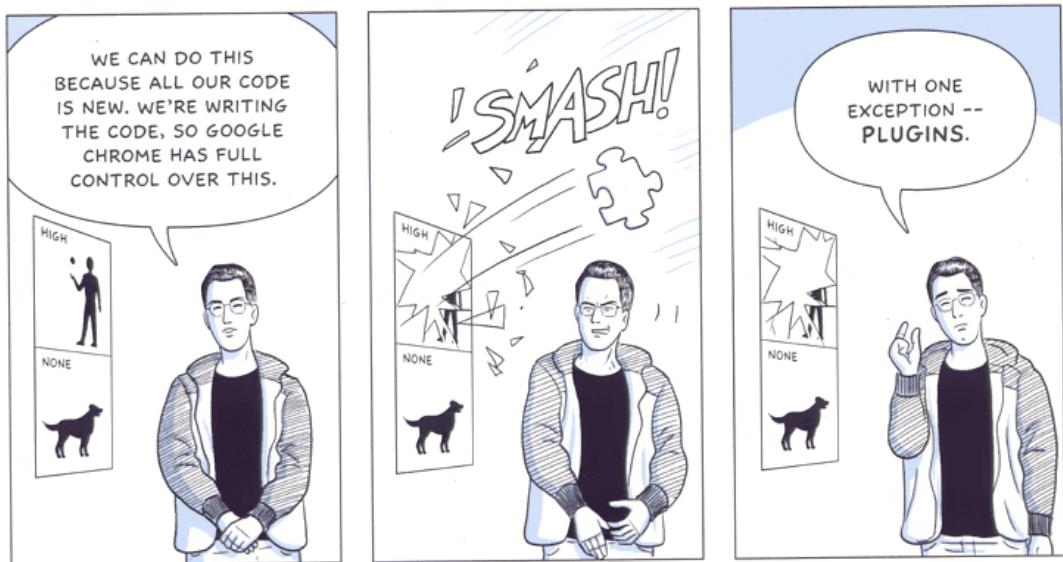
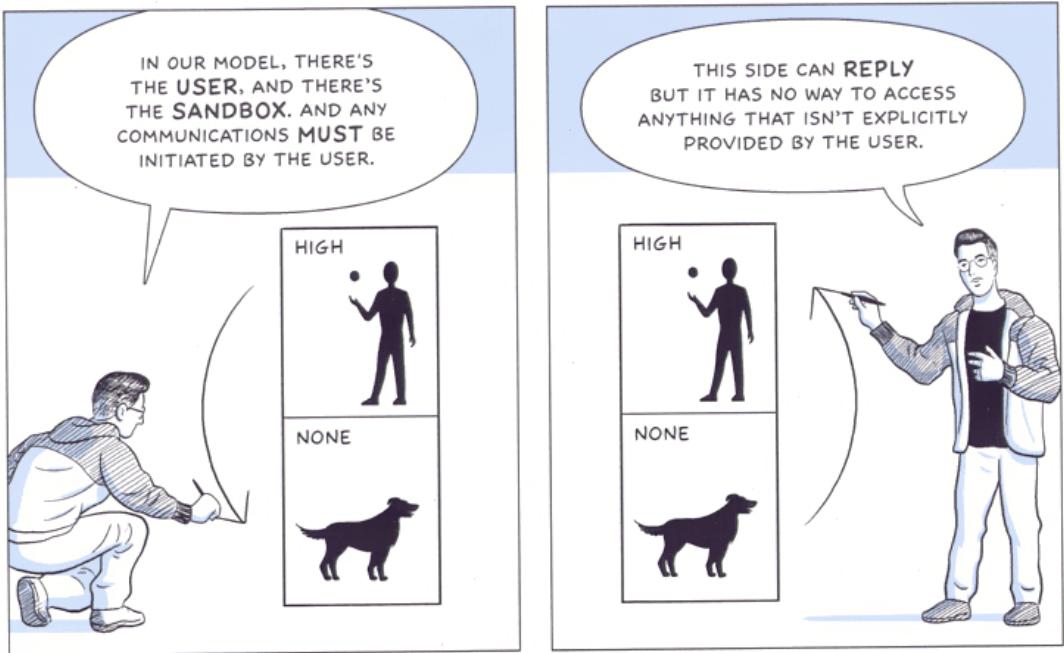


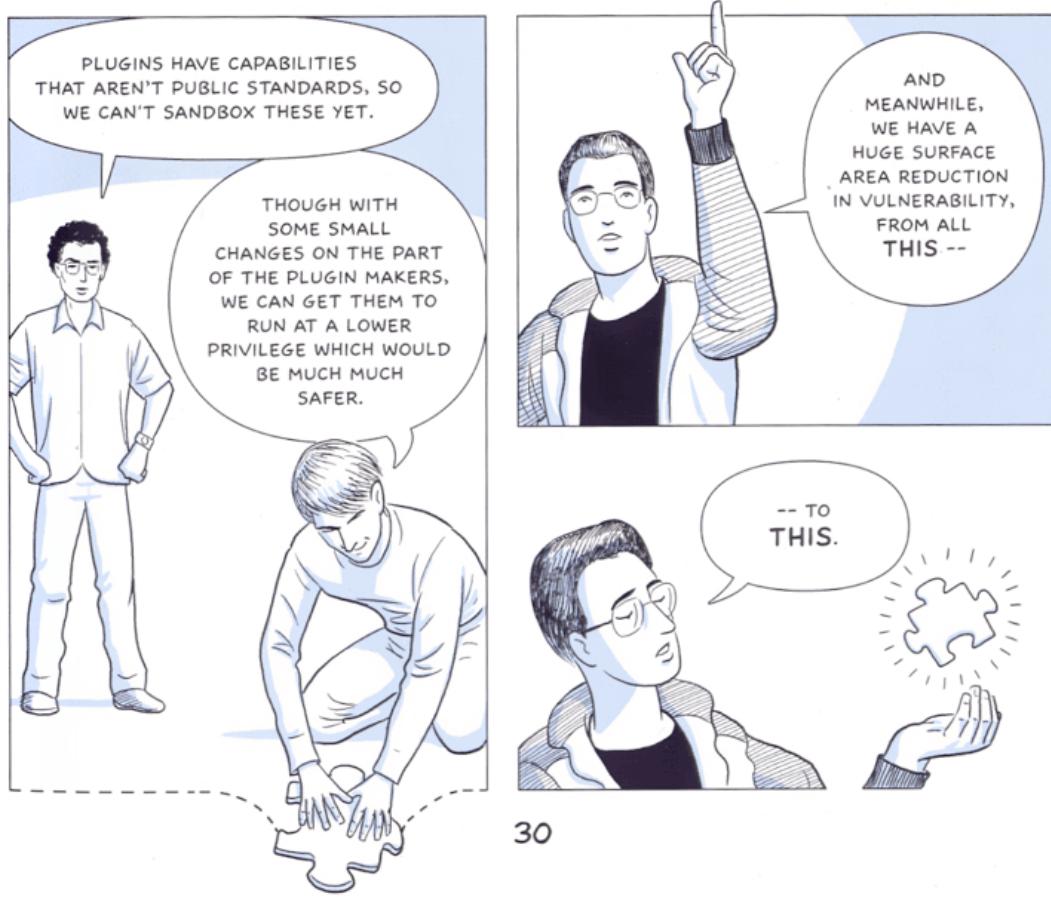
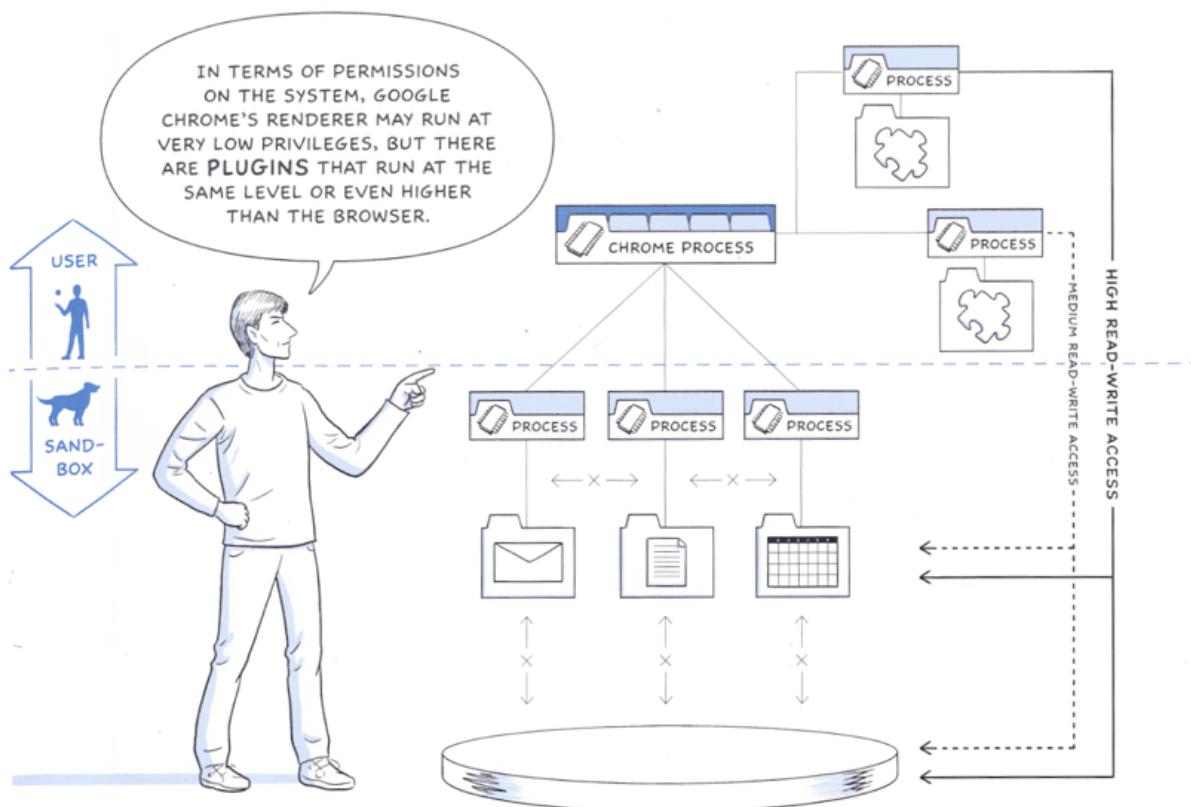


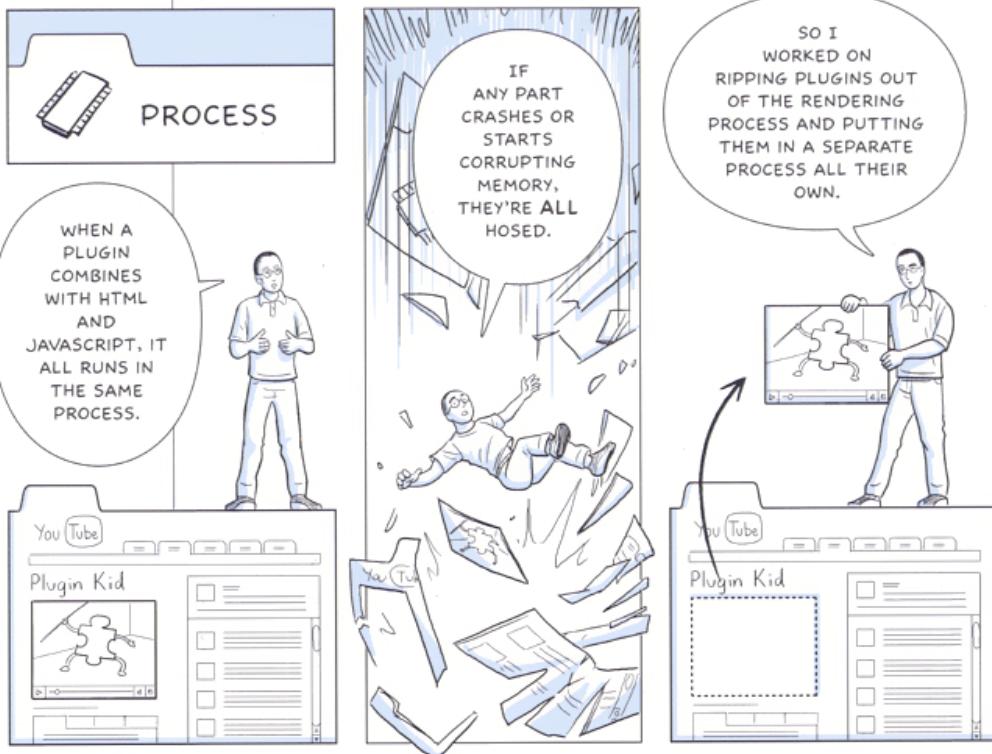


TYPICALLY, APPLICATIONS RECEIVING AND PROCESSING DATA FROM THE INTERNET ARE SPLIT INTO THE TWO LOWER LEVELS.



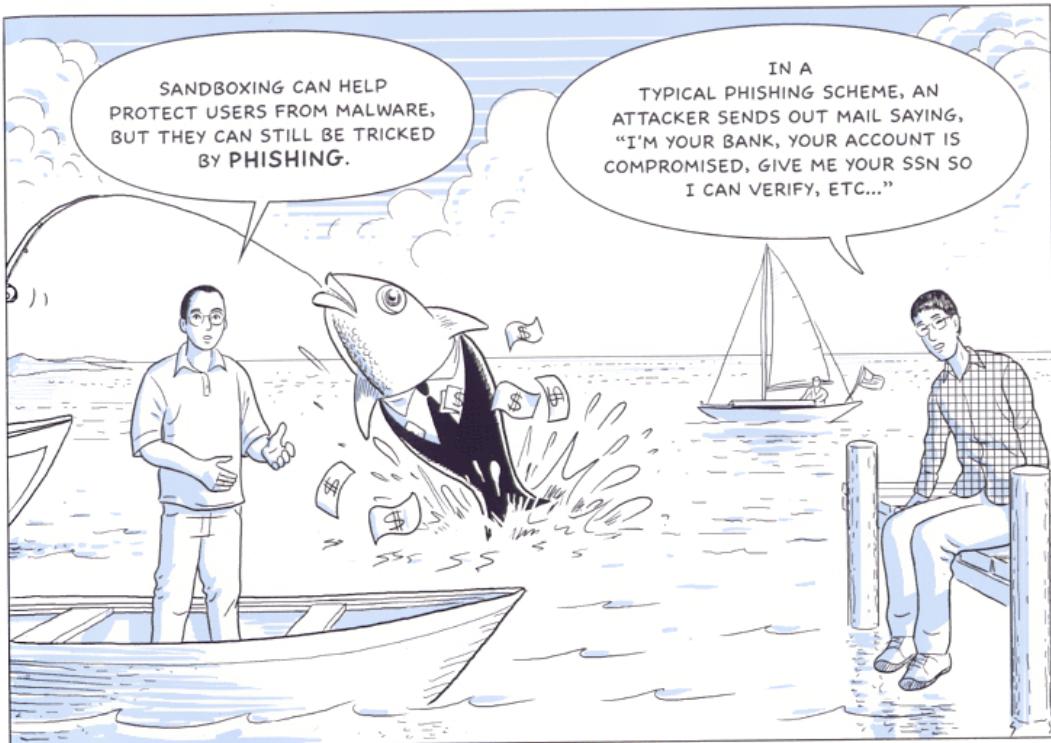


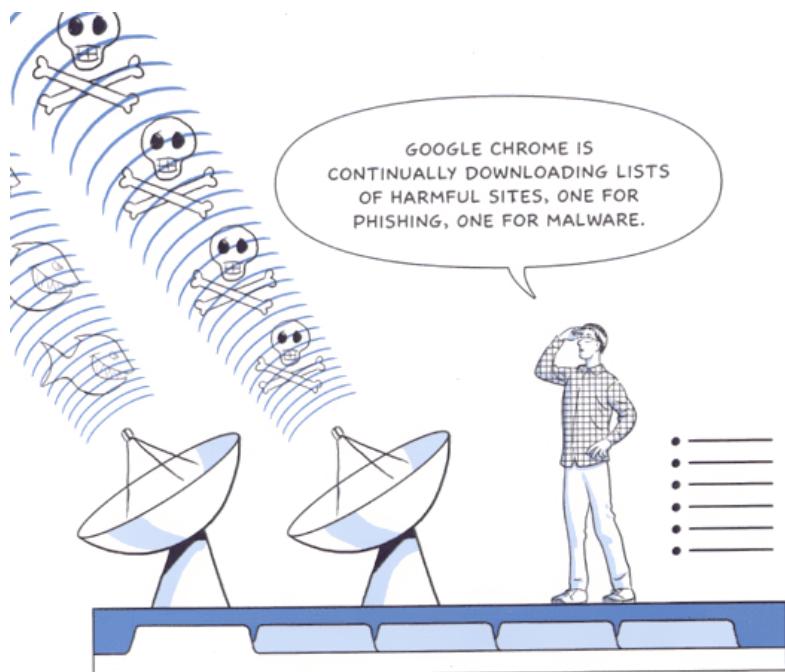




SO I WORKED ON RIPPING PLUGINS OUT OF THE RENDERING PROCESS AND PUTTING THEM IN A SEPARATE PROCESS ALL THEIR OWN.







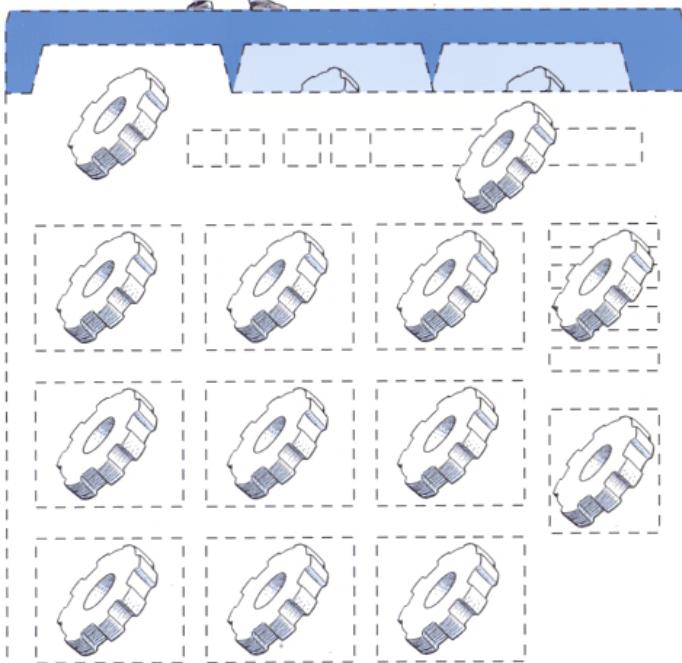
Part Five



Gears, Standards and Open Source

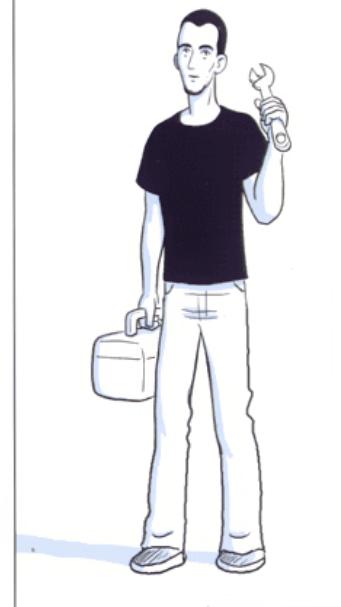


Aaron Boodman,
Software Engineer



ANOTHER THING
WE BUILT INTO
GOOGLE CHROME IS
GEARS.

GEARS BASICALLY
ADDS AN API TO
YOUR BROWSER -- AN
EXTENSION THAT
IMPROVES ITS
CAPABILITIES.



FROM MY
PERSPECTIVE, GOOGLE CHROME
AND GEARS ARE ENTERING THE WEB
FROM TWO DIRECTIONS.

THE BROWSER PROJECT IS
AN EFFORT TO MAKE THE WEB
BETTER FOR USERS.

THE GEARS TEAM WANTS
TO MAKE THE WEB BETTER
FOR DEVELOPERS.



THERE ARE A LOT OF LIMITATIONS TO THE KINDS OF APPLICATIONS THAT YOU CAN BUILD TODAY WITH WEB BROWSERS, AND THE SUBSET OF THINGS YOU CAN DO IS DIFFERENT FOR EACH BROWSER. IF ONE BROWSER HAS A COOL FEATURE, THAT DOESN'T HELP --

