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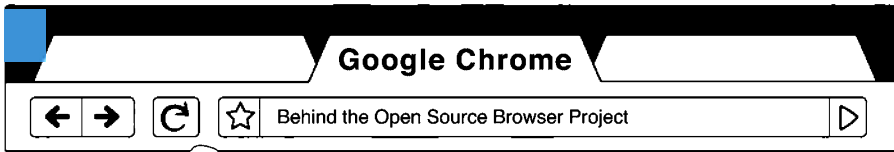
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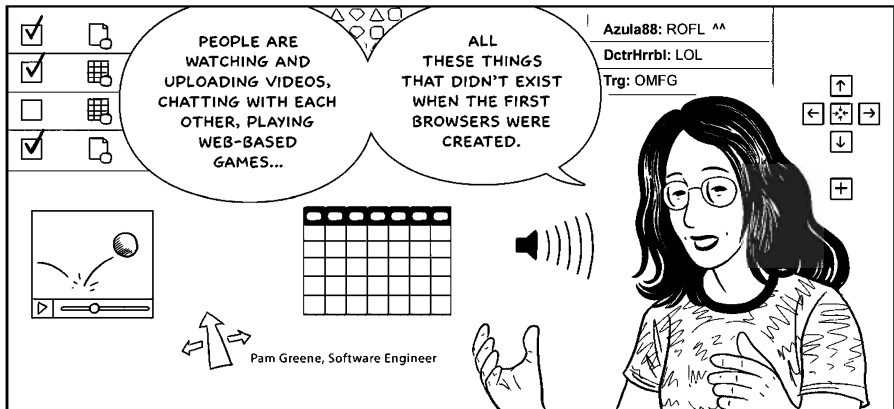


Google Chrome



Brian Rakowski,
Product Manager

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



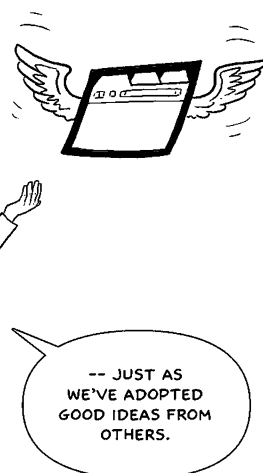
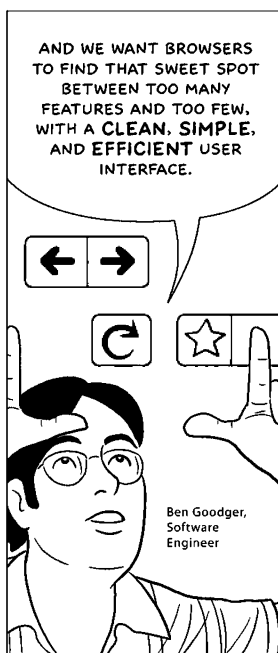
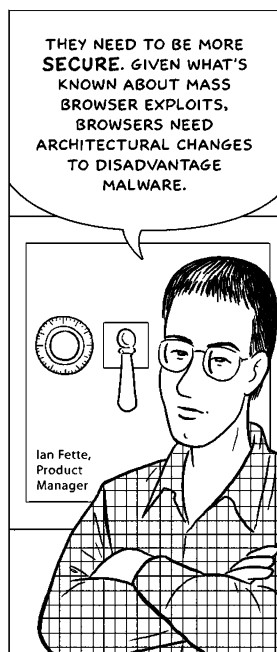
WOULDN'T
IT BE GREAT,
THEN, TO
START FROM
SCRATCH --



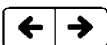
-- AND DESIGN
SOMETHING BASED
ON THE NEEDS OF
TODAY'S WEB
APPLICATIONS
AND TODAY'S
USERS?

2008





Part One



Stability, Testing and the Multi-Process Architecture



WHEN WE STARTED THIS PROJECT, THE GEARS GUYS WERE SAYING THAT ONE OF THE PROBLEMS WITH BROWSERS IS THAT THEY'RE INHERENTLY SINGLE-THREADED.



BROWSER

HTML



JAVASCRIPT

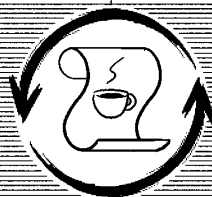


PLUGINS

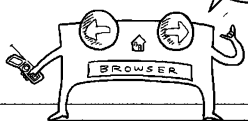


HTML

FOR EXAMPLE, ONCE YOU HAVE JAVASCRIPT EXECUTING, IT'S GOING TO KEEP GOING, AND THE BROWSER CAN'T DO ANYTHING ELSE UNTIL JAVASCRIPT RETURNS CONTROL TO THE BROWSER.



SO DEVELOPERS WRITE APIS THAT ARE ASYNCHRONOUS --

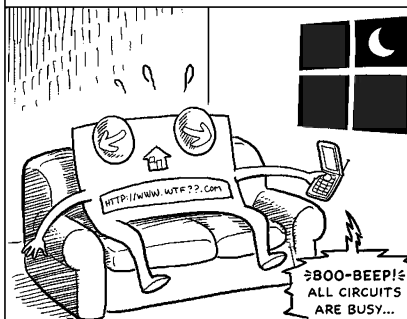


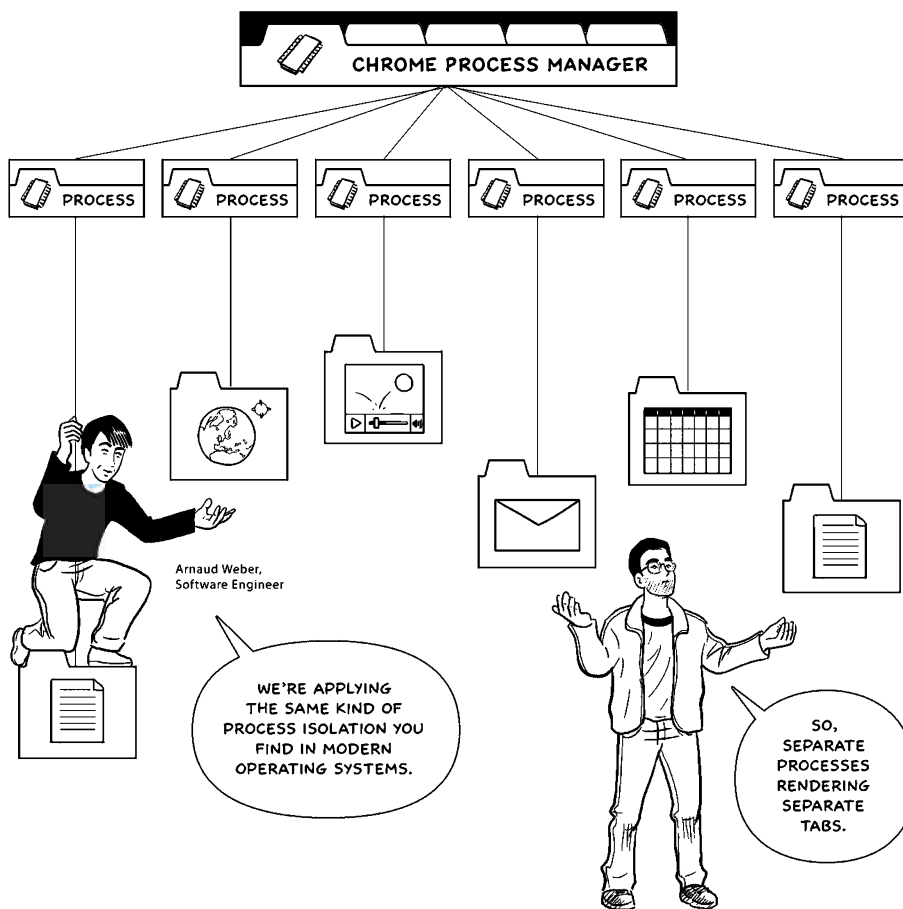
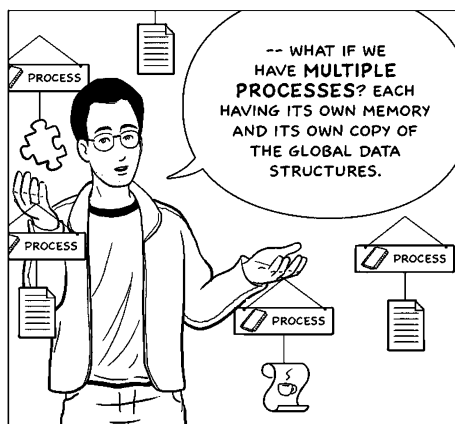
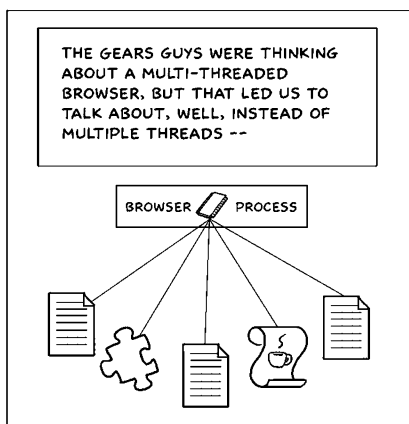
CALL ME AS SOON AS YOU'RE DONE!

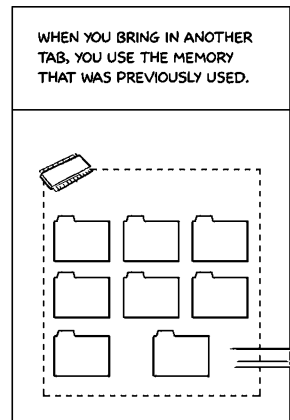
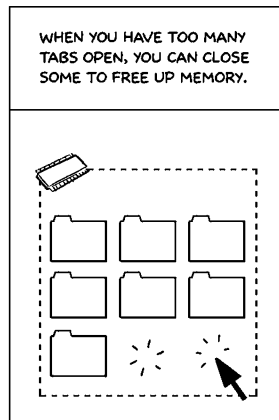
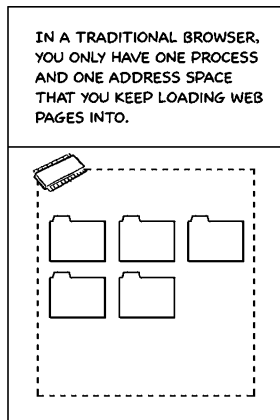
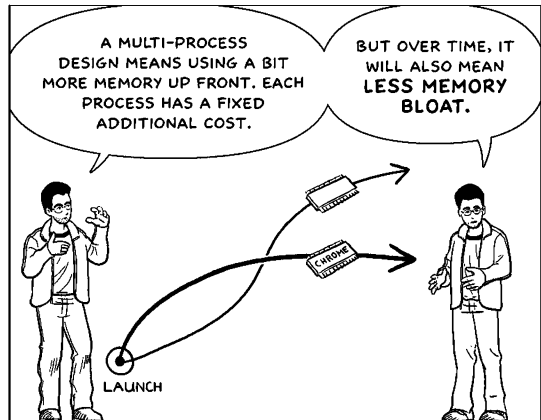
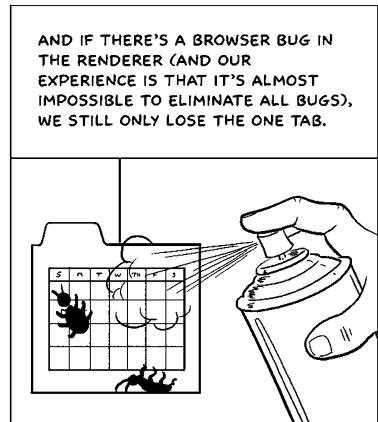
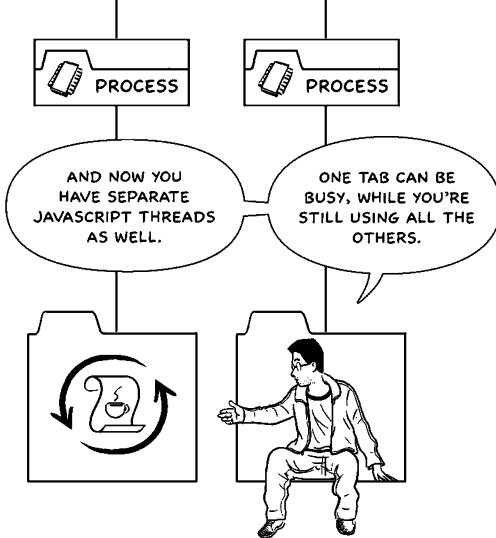
SURE THING!



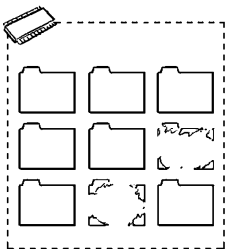
-- AND EVERY NOW AND THEN THE BROWSER LOCKS UP BECAUSE JAVASCRIPT IS HUNG UP ON SOMETHING.







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

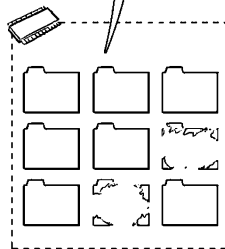


EITHER WE HAVE MEMORY THAT NOTHING CAN REFER TO AGAIN, OR THERE'S A PIECE OF DE-ALLOCATED MEMORY WE STILL HAVE POINTERS TO.

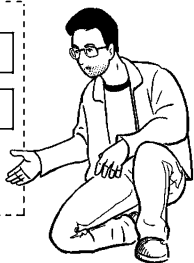
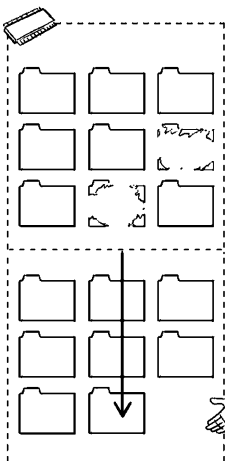


Mike Belshé,
Software Engineer

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.



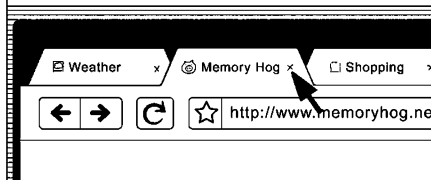
AND THIS PROBLEM GROWS ALL DAY, AS THE LIFETIME OF THE BROWSER EXTENDS.

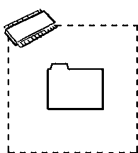
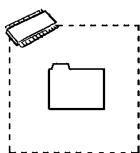
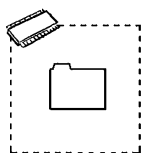
HURRY UP, DAMMIT!

TRY CLOSING SOME TABS.

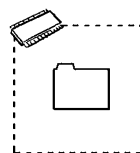


BUT WHEN A TAB IS CLOSED IN GOOGLE CHROME, YOU'RE ENDING THE WHOLE PROCESS --

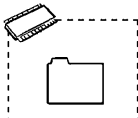




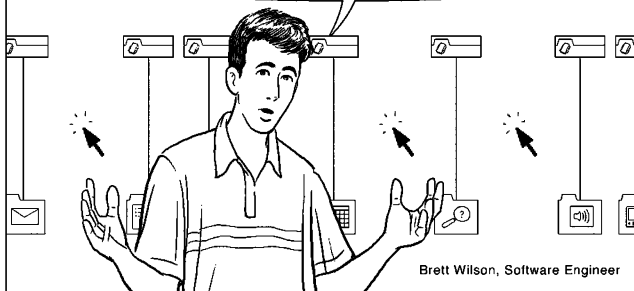
-- AND
ALL THAT
MEMORY
GETS
RECLAIMED.



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

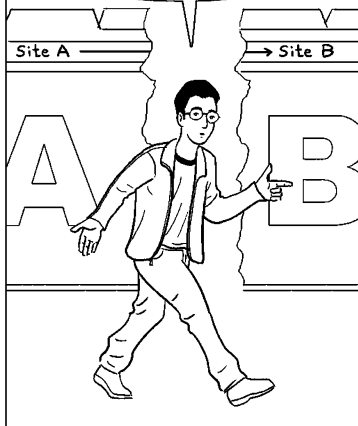


SO AS YOU BROWSE, WE'RE CREATING AND
DESTROYING PROCESSES ALL THE TIME. IF THERE'S A
CRAZY MEMORY LEAK IT WON'T AFFECT YOU FOR THAT LONG
BECAUSE YOU'LL PROBABLY CLOSE THE TAB AT SOME
POINT AND GET THAT MEMORY BACK.

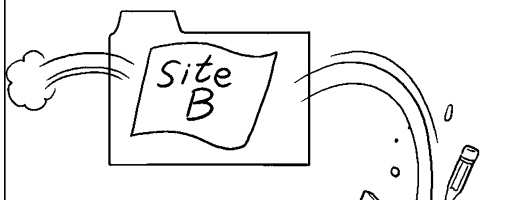


Brett Wilson, Software Engineer

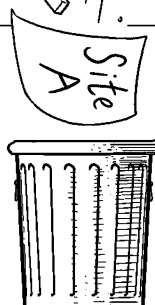
AND WE'RE TAKING IT ONE
STEP FURTHER. SUPPOSE YOU
NAVIGATE FROM DOMAIN A TO
DOMAIN B. THERE'S NO NEED FOR
ANY RELATIONSHIP BETWEEN
THE TWO SITES --

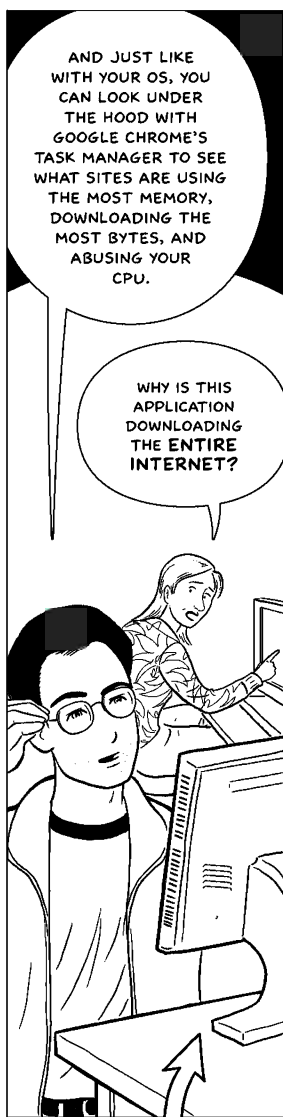


-- SO NOW WE CAN THROW AWAY THE
OLD RENDERING ENGINE, THE OLD DATA
STRUCTURES, THE OLD PROCESS.

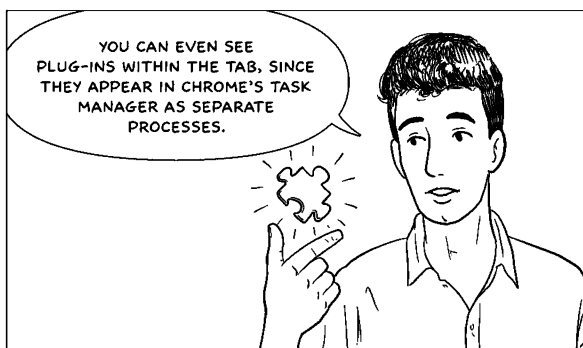


SO, EVEN WITHIN A
TAB, WE CAN BE
COLLECTING AND
TOSSING OUT THE
GARBAGE,
RECYCLING THE
WHOLE PROCESS.

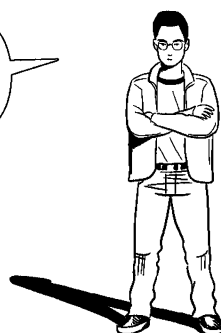
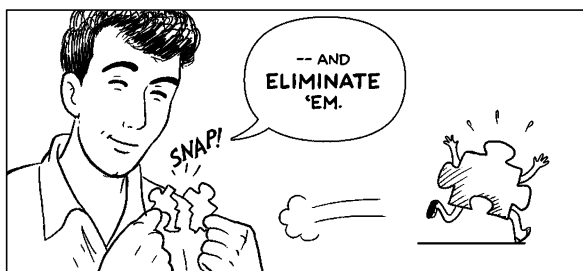
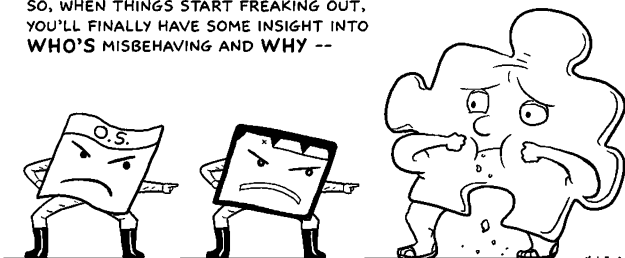




	Memory	CPU	Network
hivore	74,000K	0	0
nes from Mail	0	0	0
ogle.com	14,768K	0	0
by 2008	0	0	0
s - All Items	17,200K	1	0
adsheets	0	0	0



SO, WHEN THINGS START FREAKING OUT, YOU'LL FINALLY HAVE SOME INSIGHT INTO WHO'S MISBEHAVING AND WHY --

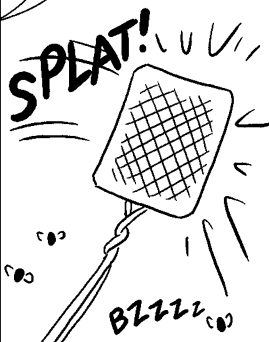




WITHIN 20-30 MINUTES OF EACH NEW BROWSER BUILD, WE CAN TEST IT ON TENS OF THOUSANDS OF DIFFERENT WEB PAGES.

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

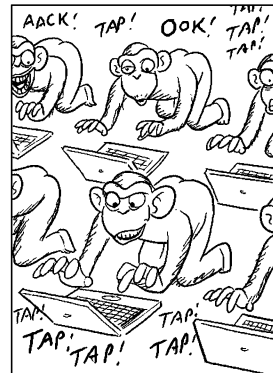
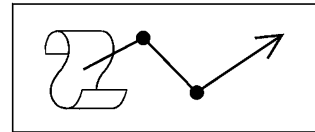
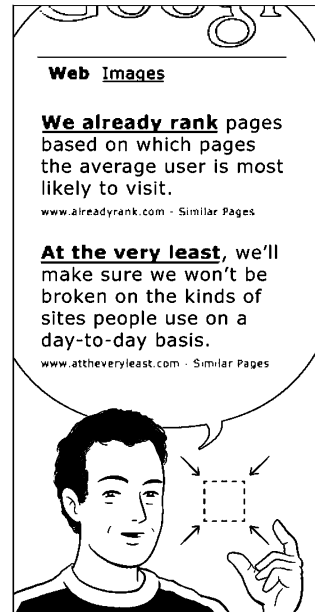
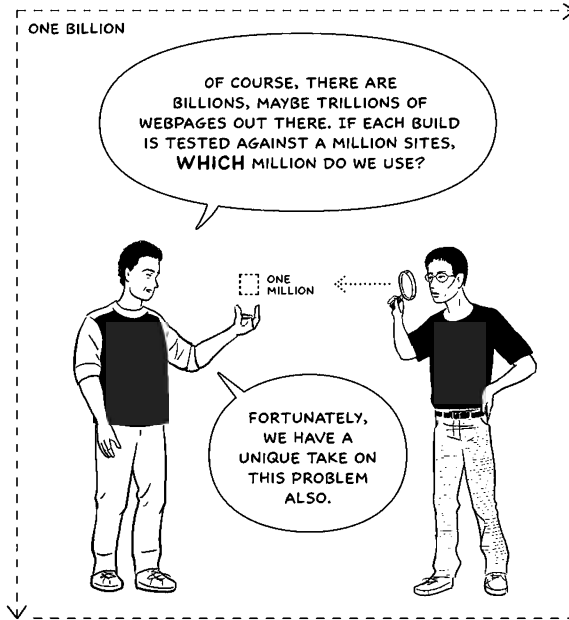
THE KEY IS CATCHING PROBLEMS AS EARLY AS POSSIBLE. IT IS LESS EXPENSIVE AND EASIER TO FIX THEM RIGHT AWAY. AFTER A FEW DAYS IT IS HARDER TO TRACK THEM DOWN.

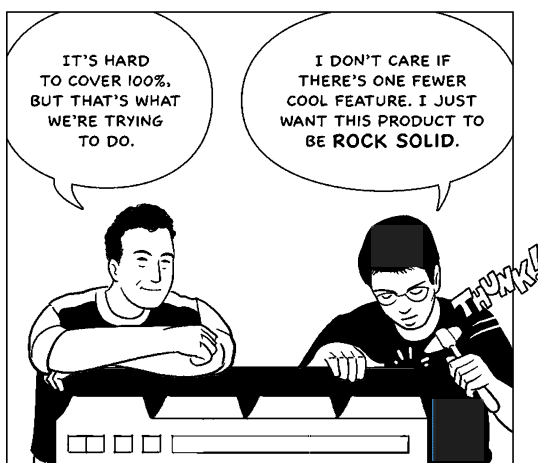
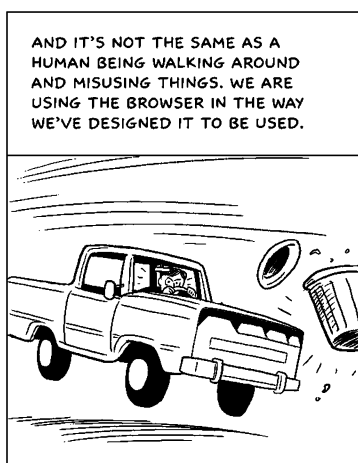
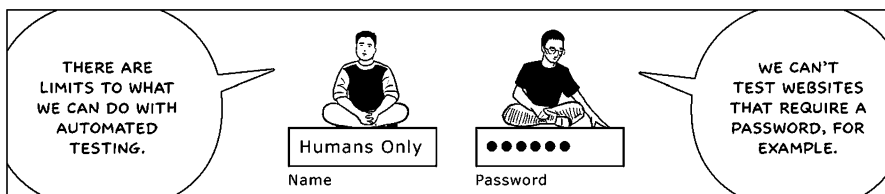
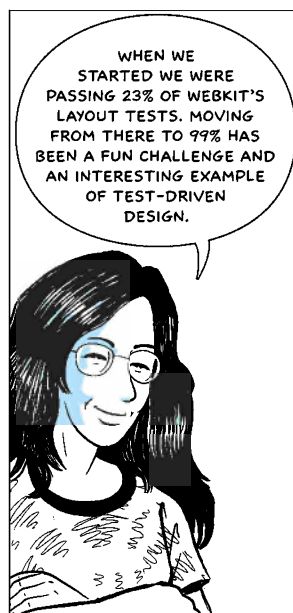
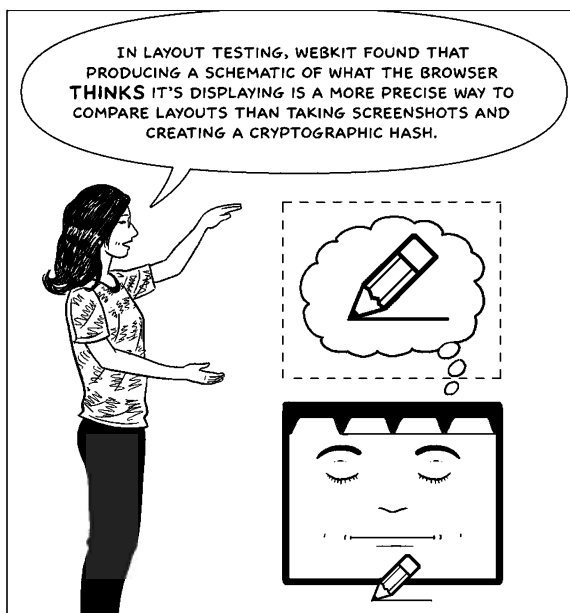


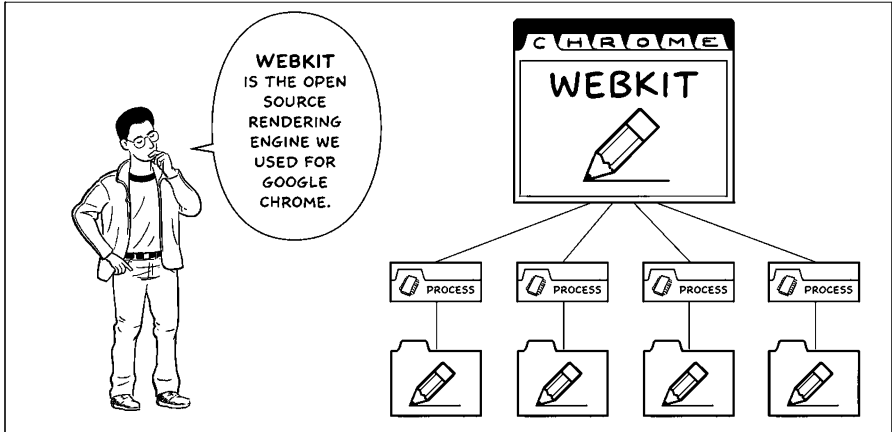
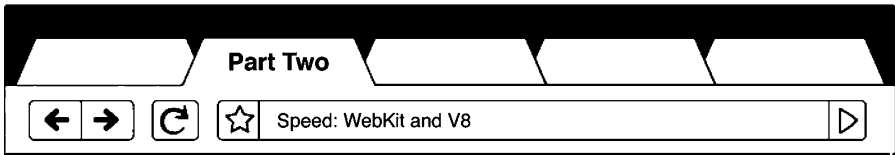
AND CATCHING THEM EARLY HELPS ENGINEERS WRITE BETTER CODE. THEY SAY, "OH, THIS MISTAKE IS PART OF A PATTERN" AND THE NEXT TIME, THEY'RE LESS LIKELY TO MAKE IT.



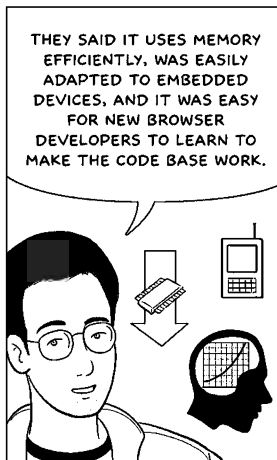
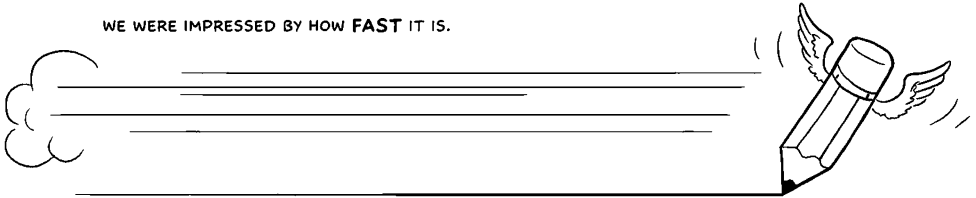
Erik Kay, Software Engineer

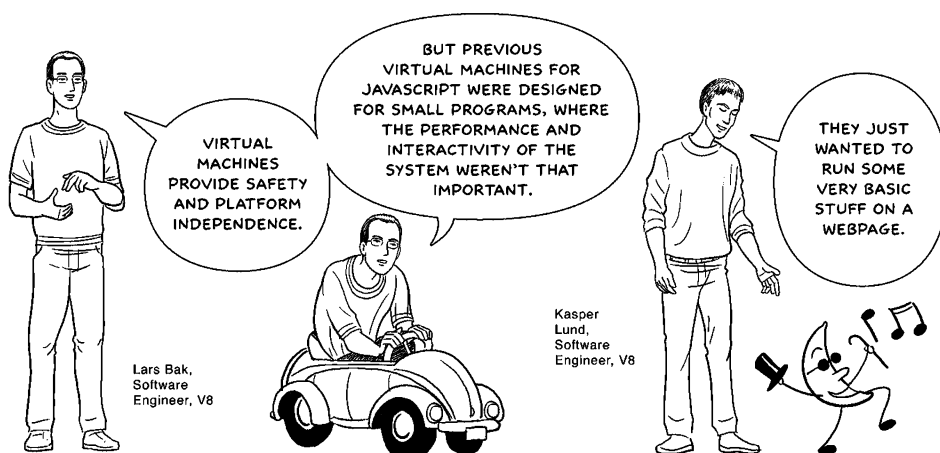
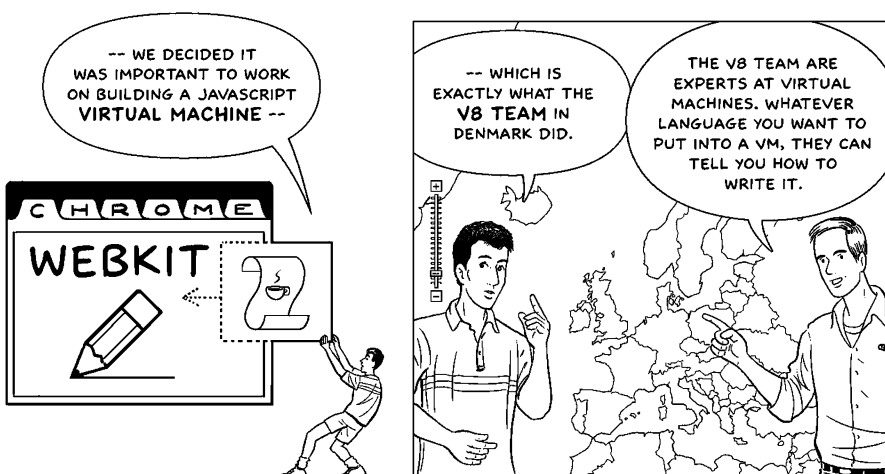
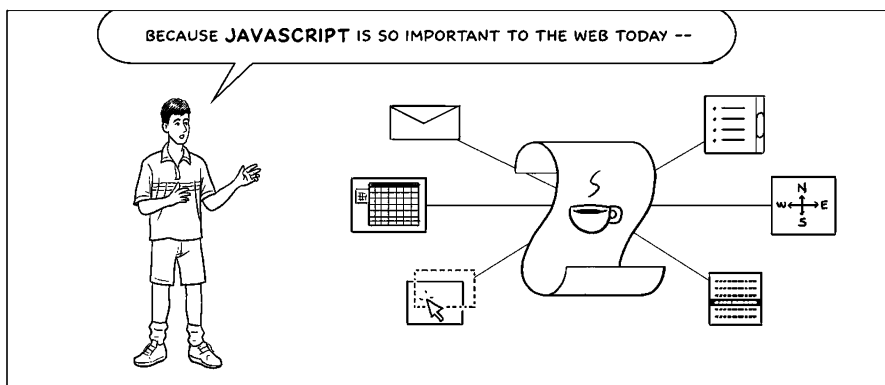






WE WERE IMPRESSED BY HOW **FAST** IT IS.





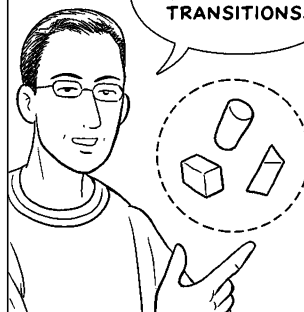
BUT NOW,
YOU HAVE WEB APPLICATIONS LIKE
GMAIL THAT ARE USING THE WEB
BROWSER TO ITS FULLEST WHEN IT COMES
TO DOM MANIPULATIONS AND
JAVASCRIPT --

-- AND THAT
SIMPLISTIC APPROACH TO
JAVASCRIPT ENGINES ISN'T
ENOUGH ANYMORE.

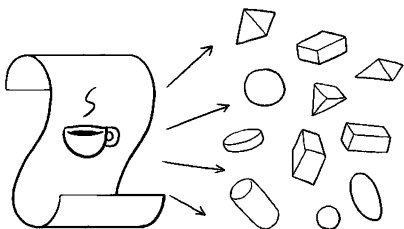


SO WE STARTED WITH
NO CODE, JUST SOME WILD
IDEAS ABOUT HOW TO MAKE
IT GO REALLY FAST --

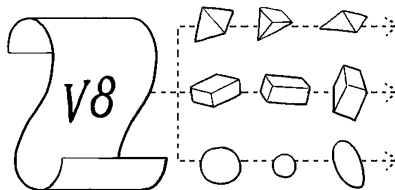
-- SUCH AS
INTRODUCING
**HIDDEN CLASS
TRANSITIONS.**



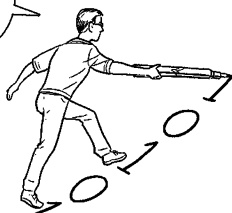
JAVASCRIPT ITSELF IS **CLASSLESS**.
YOU CAN CREATE A NEW OBJECT,
DYNAMICALLY ADD PROPERTIES TO
IT AND GO ON.



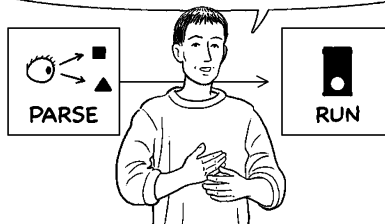
BUT IN **V8**, AS EXECUTION GOES ON,
OBJECTS THAT END UP WITH THE SAME
PROPERTIES WILL SHARE THE SAME HIDDEN
CLASS AND WE CAN START APPLYING
DYNAMIC OPTIMIZATIONS BASED ON THAT.

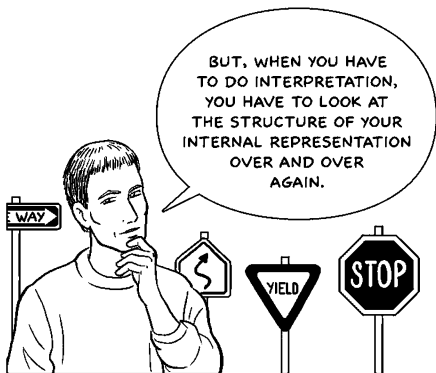


ANOTHER FACTOR
IN V8'S SPEED IS
DYNAMIC CODE
GENERATION.

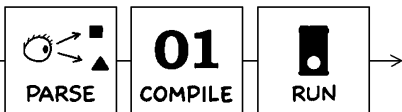


WHEN OTHER JAVASCRIPT ENGINES RUN, THEY
LOOK AT THE JAVASCRIPT SOURCE CODE AND
GENERATE AN INTERNAL REPRESENTATION OF IT
THEY CAN INTERPRET.





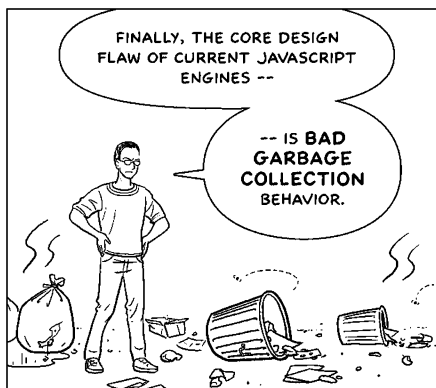
SO INSTEAD, V8 LOOKS AT THE JAVASCRIPT SOURCE CODE AND GENERATES **MACHINE CODE** THAT CAN RUN DIRECTLY ON THE CPU THAT'S RUNNING THE BROWSER.



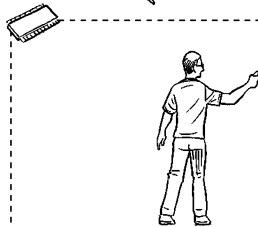
WHEN YOU INTERPRET ONCE AND COMPILE MACHINE CODE, THEN THAT CODE **IS** YOUR REPRESENTATION OF THE JAVASCRIPT SOURCE CODE AND IT DOESN'T NEED TO BE INTERPRETED, IT JUST RUNS.



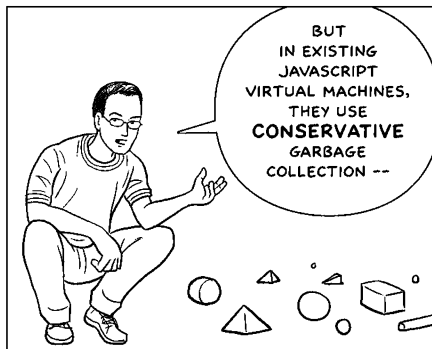
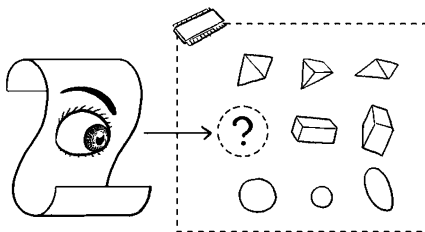
1 1 0 1 0 1 0 0 0 1 0 1 0 0 0 1 0 1 0 1 0 0 1 0 1 0 1 0 0 0 0 1 0 1 0 1 0 0 0 0 1 0 1 0 1 0

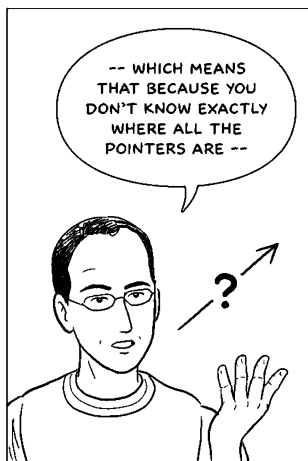


JAVASCRIPT AND OTHER MODERN OBJECT-ORIENTED PROGRAMMING LANGUAGES HAVE **AUTOMATIC MEMORY MANAGEMENT**.



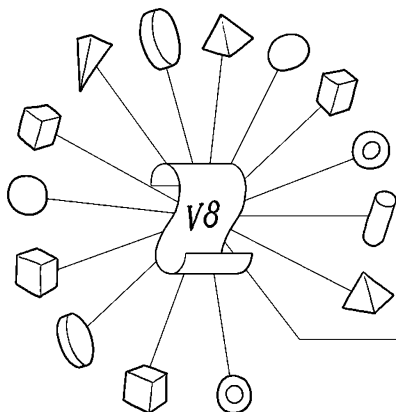
IF YOU DON'T HAVE A REFERENCE TO AN OBJECT ANYMORE, ITS MEMORY CAN BE **RECLAIMED** BY THE SYSTEM. THAT'S GARBAGE COLLECTION, AND ITS A FAIRLY TRIVIAL PROCESS.





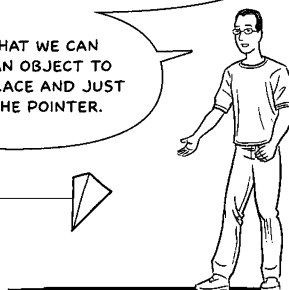
-- YOU START SEARCHING THROUGH THE EXECUTION STACK TO SEE WHICH WORDS LOOK LIKE POINTERS.

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.

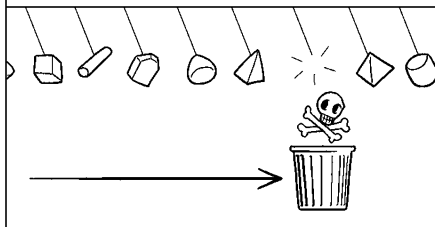


IN V8, WE ARE USING **PRECISE** GARBAGE COLLECTION, SO WE KNOW PRECISELY WHERE **ALL** OF THE POINTERS ARE ON THE STACK AND THIS GIVES US SEVERAL ADVANTAGES.

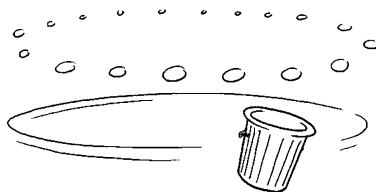
ONE IS THAT WE CAN MIGRATE AN OBJECT TO ANOTHER PLACE AND JUST REWIRE THE POINTER.

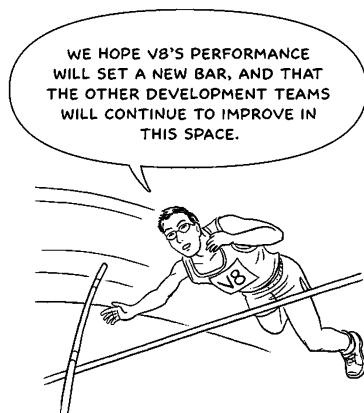
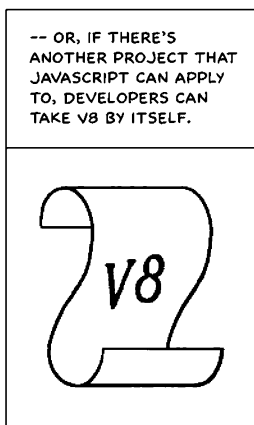
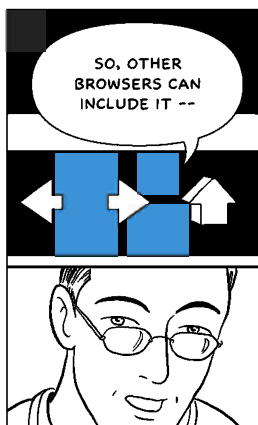
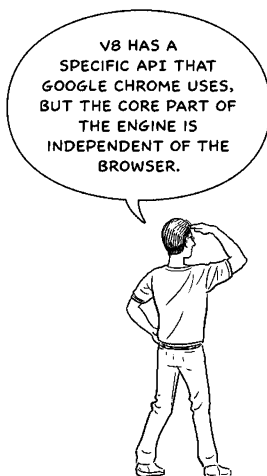
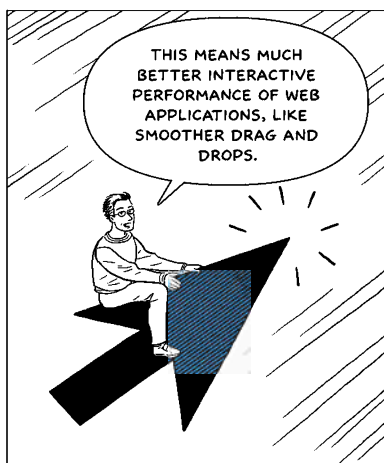


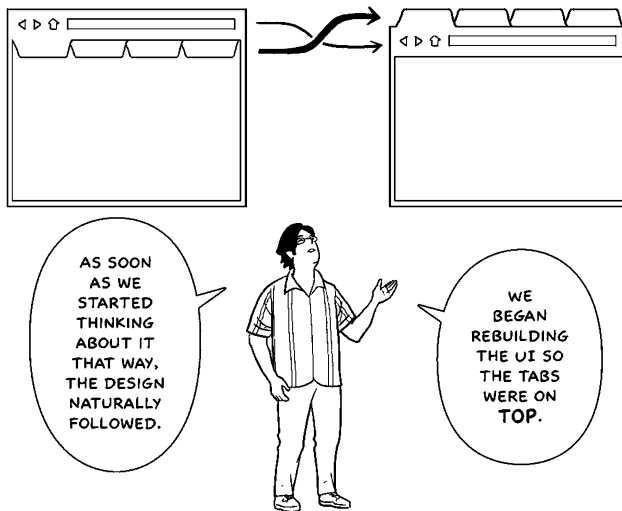
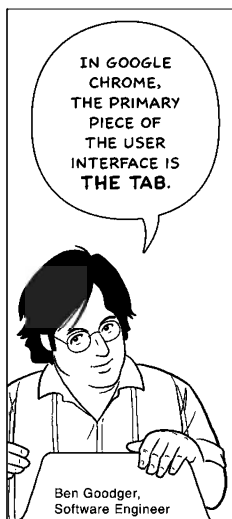
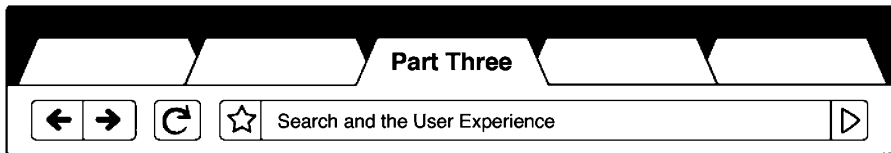
AND, BECAUSE WE KNOW PRECISELY WHERE ALL THE POINTERS ARE, WE CAN ALSO IMPLEMENT **INCREMENTAL** GARBAGE COLLECTION.



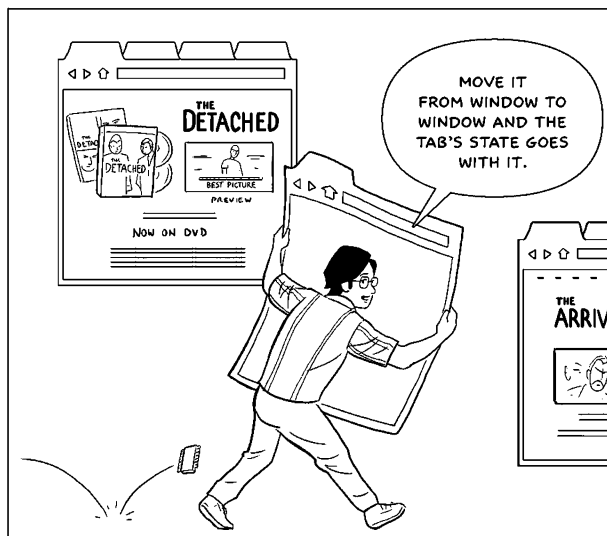
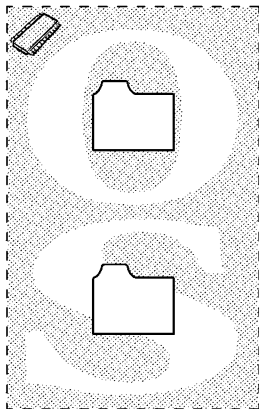
MEANING QUICK GARBAGE COLLECTION ROUND-TRIPS THAT ARE CLOSE TO A FEW MILLISECONDS, COMPARED TO PROCESSING ALL 100MB OF DATA WHICH COULD CAUSE SECOND-LONG PAUSES.

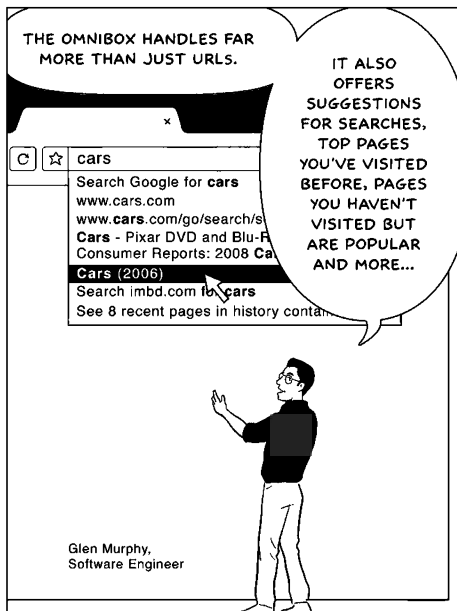
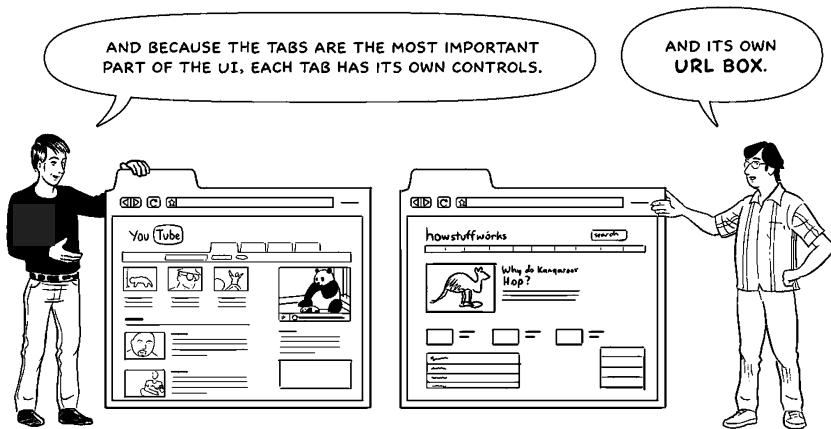


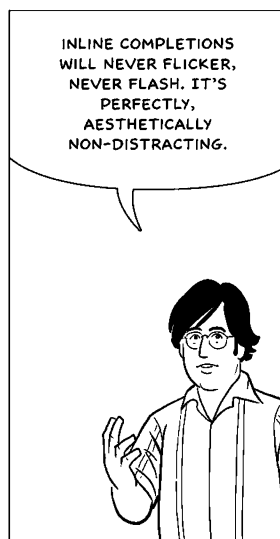




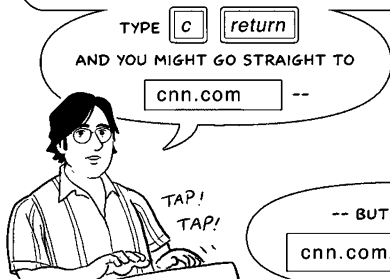
WE COULD DETACH THE TABS EASILY BECAUSE OF THE SEPARATION OF THE BROWSER AND TAB PROCESSES.



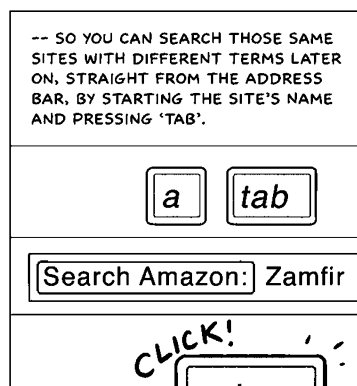
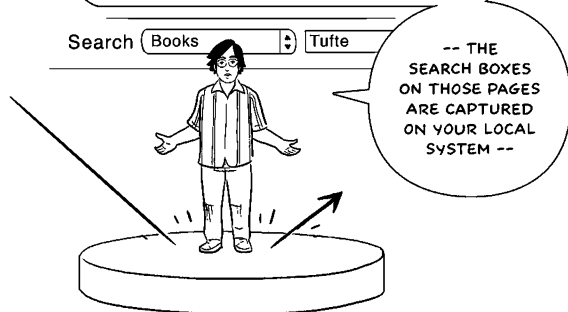




PLUS, IT'LL ONLY AUTOCOMPLETE TO SOMETHING YOU'VE EXPLICITLY TYPED BEFORE.



AND WHEN YOU SEARCH ON SITES LIKE
AMAZON, WIKIPEDIA OR EVEN GOOGLE --

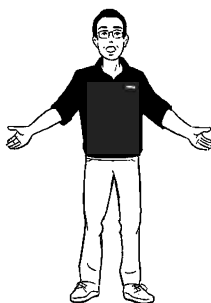


OPEN A NEW TAB IN
MOST BROWSERS TODAY,
AND YOU'LL GET YOUR
HOMEPAGE.

SOME USERS
HAVE A BLANK
PAGE BECAUSE
IT OPENS
QUICKLY.



BUT THE ACTION
OF OPENING A TAB IS A
**STATEMENT OF
INTENT: YOU WANT TO
GO SOMEPLACE!**



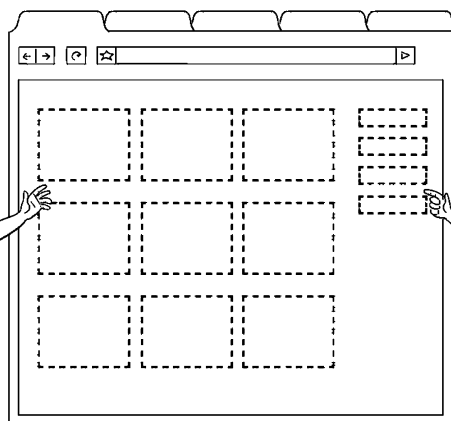
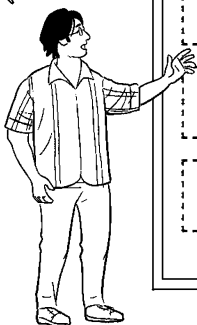
MAYBE YOU
KNOW **WHERE**.
MAYBE YOU DON'T
KNOW AND NEED TO
SEARCH.



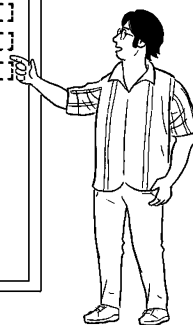
WE'RE GOING TO SHOW A PAGE
THAT IS DESIGNED TO BE FAST,
BUT ALSO HELPS YOU COMPLETE
THAT ACTION.



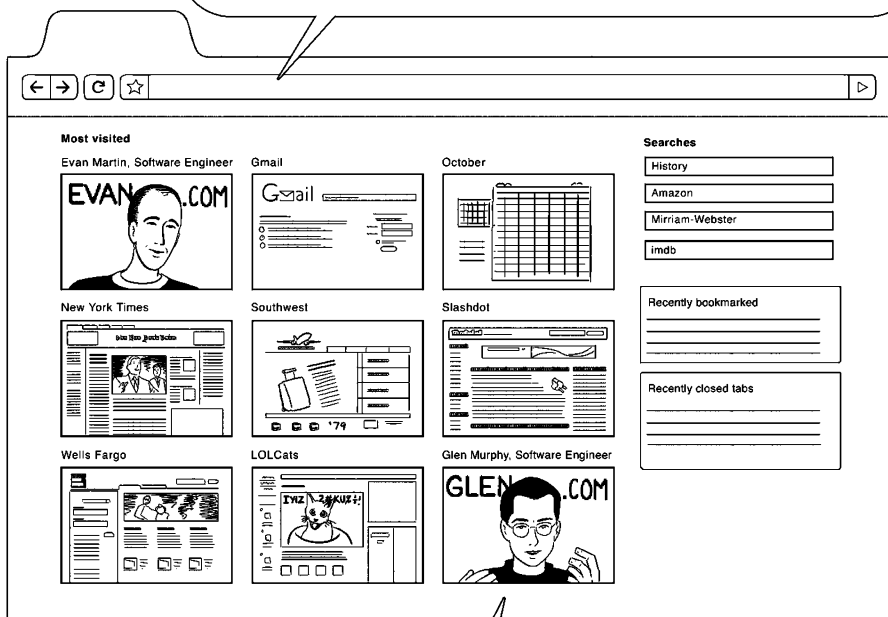
OUR
DEFAULT
EXPERIENCE,
THEN, IS THE **NEW
TAB PAGE** WITH
YOUR NINE MOST
VISITED PAGES
HERE --



-- AND THE
SITES YOU
SEARCH ON
MOST **HERE**.



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.

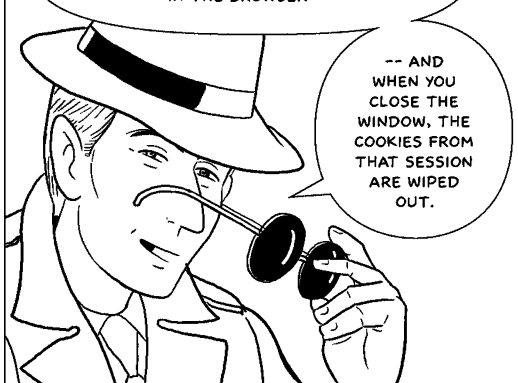


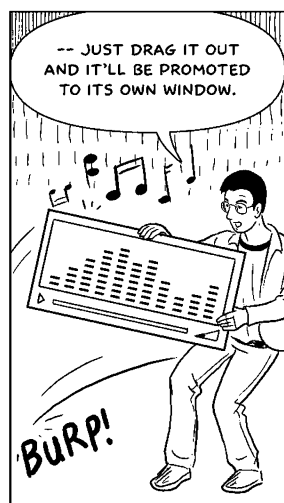
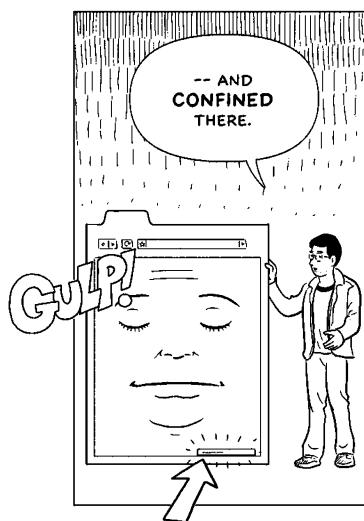
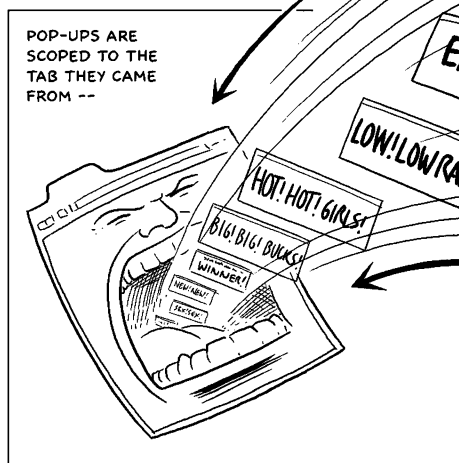
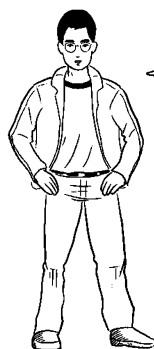
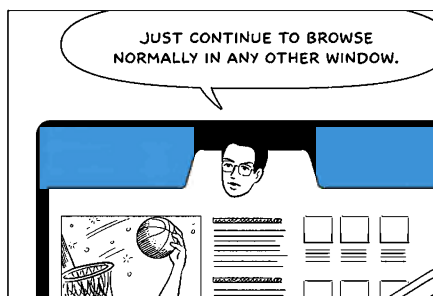
YOU MIGHT OPEN IT AND BE, LIKE, WHAT'S ALL MY STUFF DOING HERE? BUT
AFTER A WHILE, YOU SEE THIS PAGE AND IT'S JUST YOU, IT'S **YOUR** BROWSER.

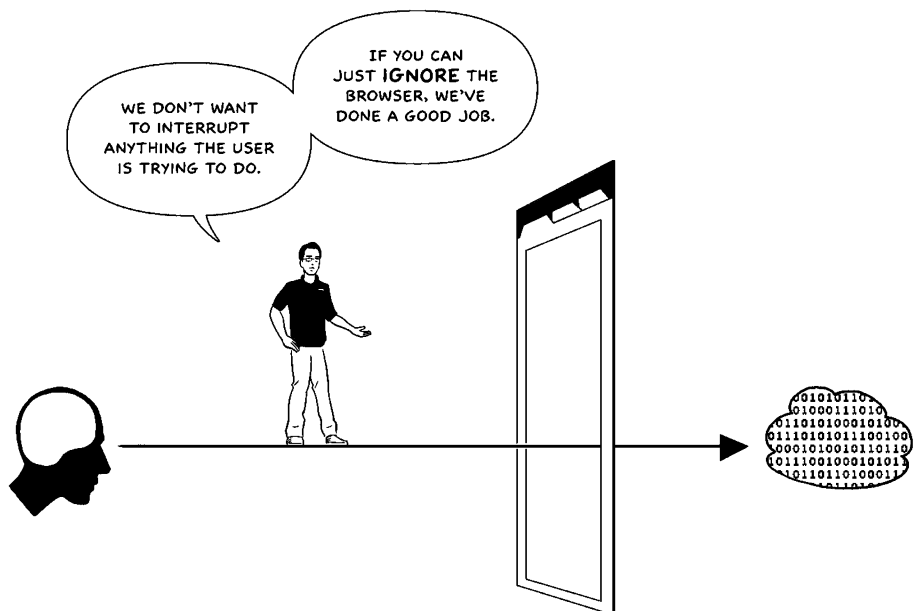
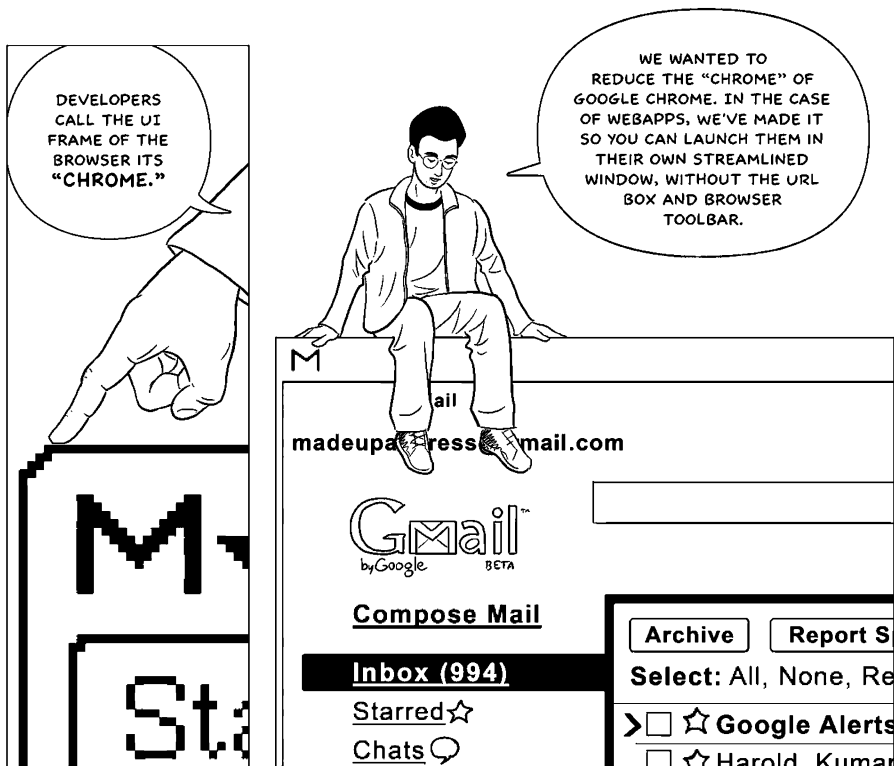
GOOGLE CHROME HAS A PRIVACY
MODE. YOU CAN CREATE AN
'INCOGNITO' WINDOW AND NOTHING
THAT OCCURS IN THAT WINDOW IS
EVER LOGGED ON YOUR COMPUTER.

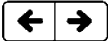


IT'S A READ-ONLY MODE: YOU
CAN STILL ACCESS YOUR BOOKMARKS,
BUT NONE OF YOUR HISTORY IS SAVED
IN THE BROWSER --









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.

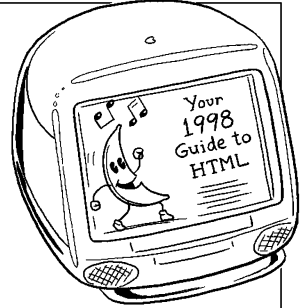


Ian Fette,
Product Manager



John Abd-El-Malek,
Software Engineer

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.

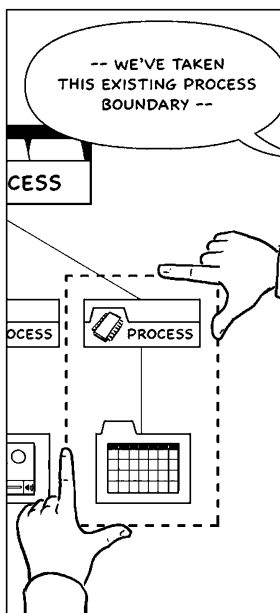
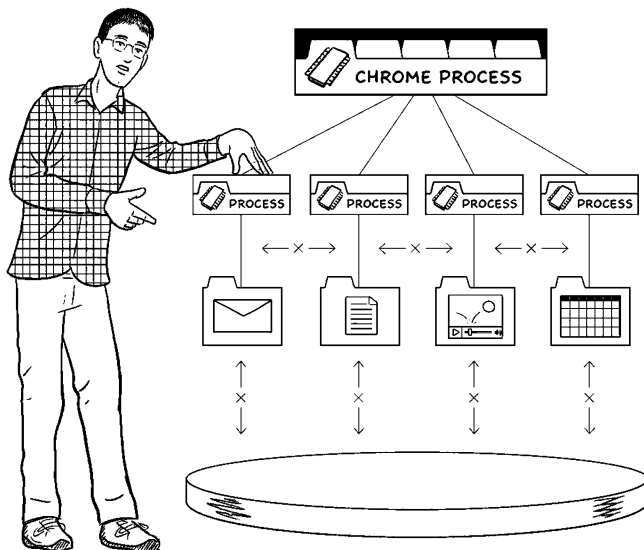


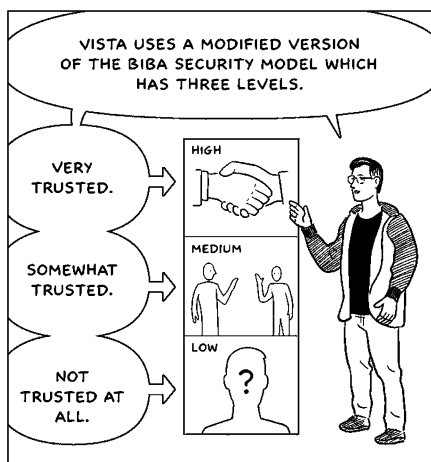
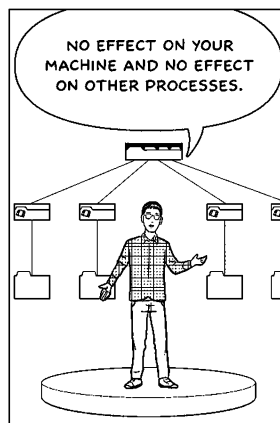
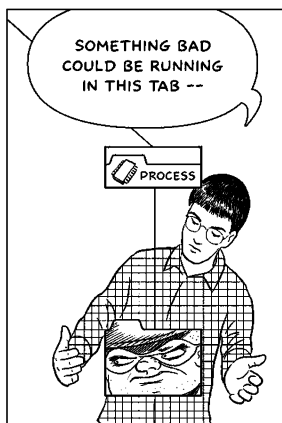
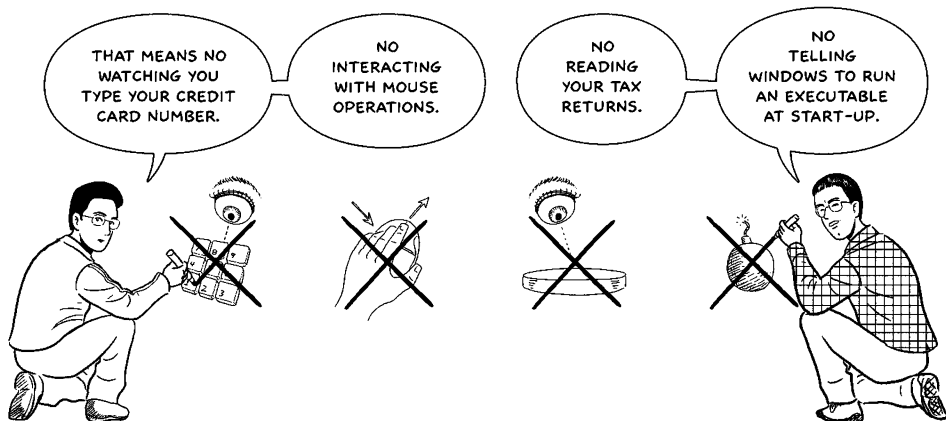
Carlos Pizano,
Software Engineer

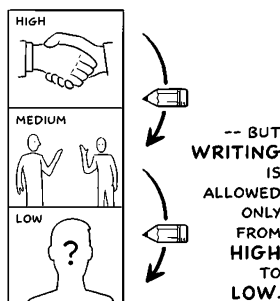
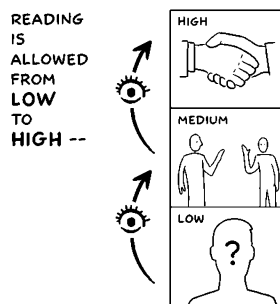
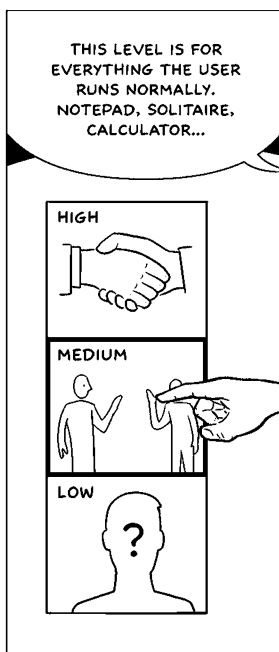
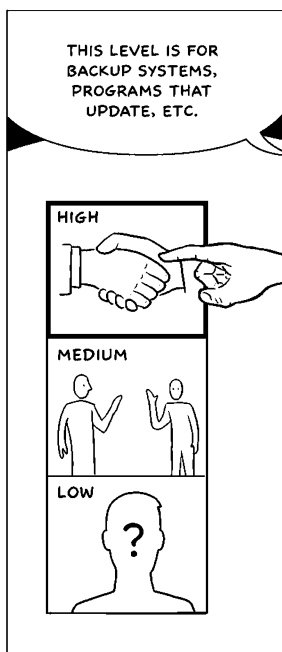
WITH **SANDBOXING**, OUR GOAL IS TO PREVENT MALWARE FROM INSTALLING ITSELF ON YOUR COMPUTER OR USING WHAT HAPPENS IN ONE TAB TO AFFECT WHAT HAPPENS IN ANOTHER.

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

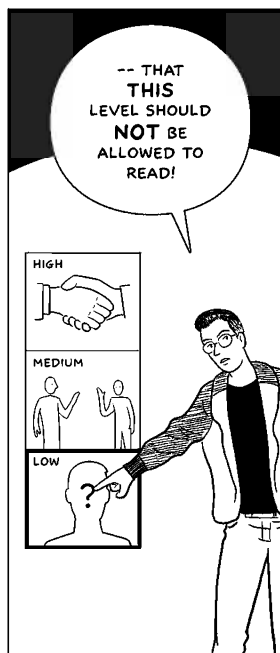
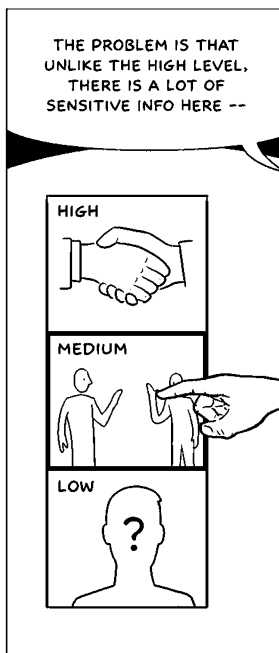
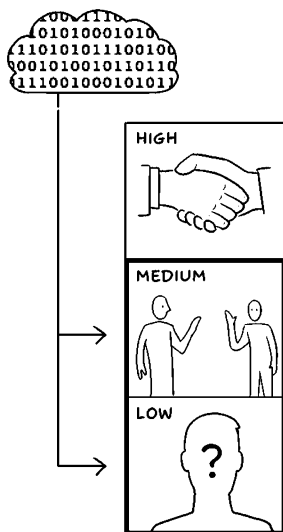
THEY CAN COMPUTE BUT THEY CAN'T WRITE FILES TO YOUR HARD DRIVE OR READ FILES FROM SENSITIVE AREAS LIKE YOUR DOCUMENTS OR DESKTOP.

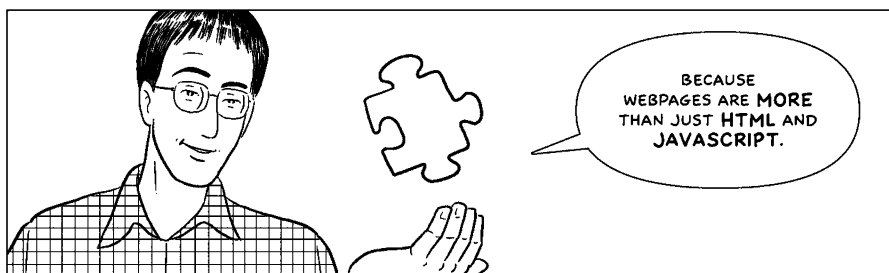
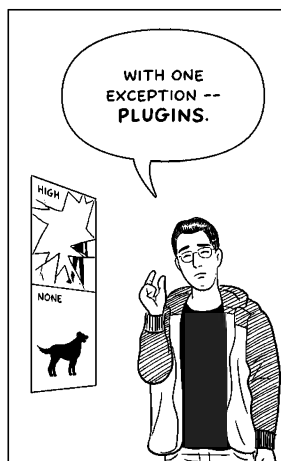
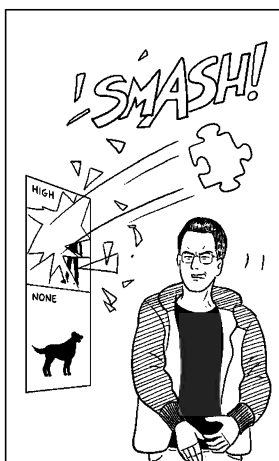
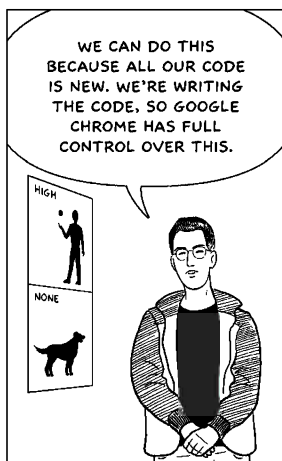
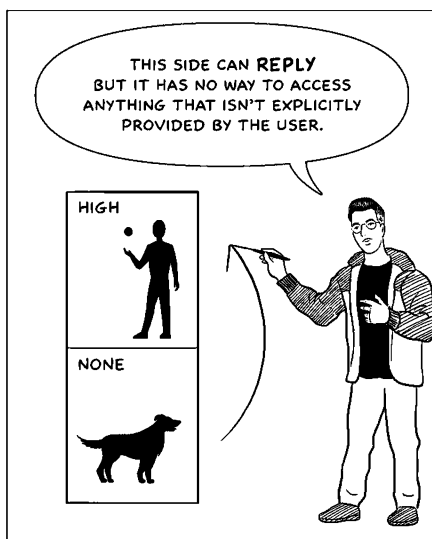
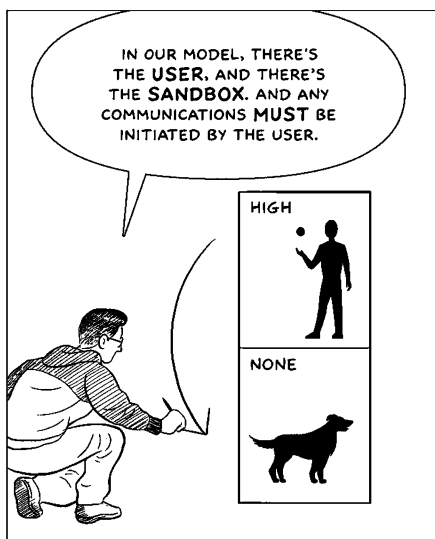


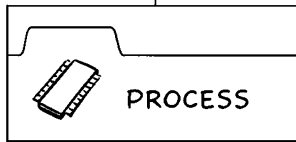




TYPICALLY, APPLICATIONS
RECEIVING AND PROCESSING
DATA FROM THE INTERNET
ARE SPLIT INTO THE TWO
LOWER LEVELS.



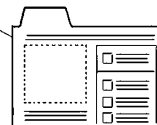
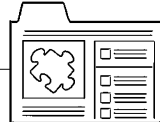
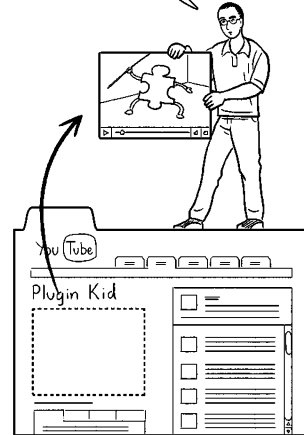




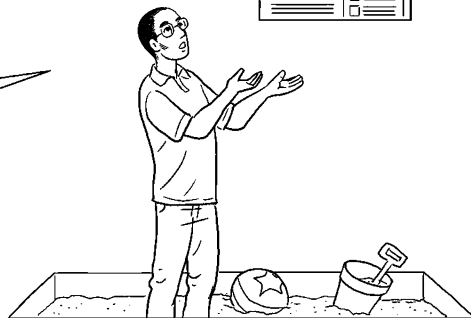
WHEN A
PLUGIN
COMBINES
WITH HTML
AND
JAVASCRIPT, IT
ALL RUNS IN
THE SAME
PROCESS.



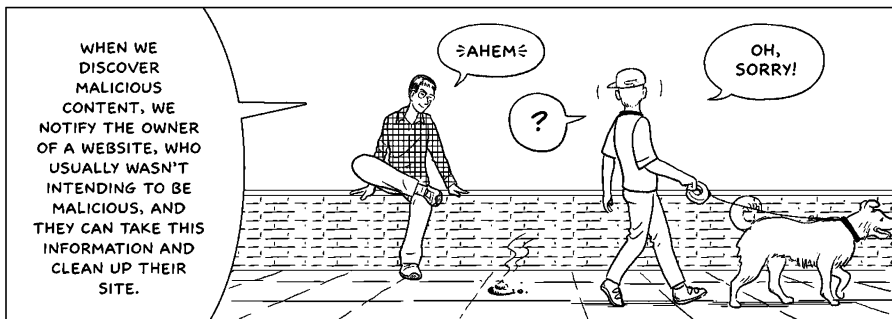
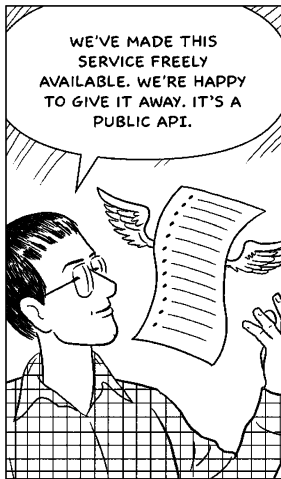
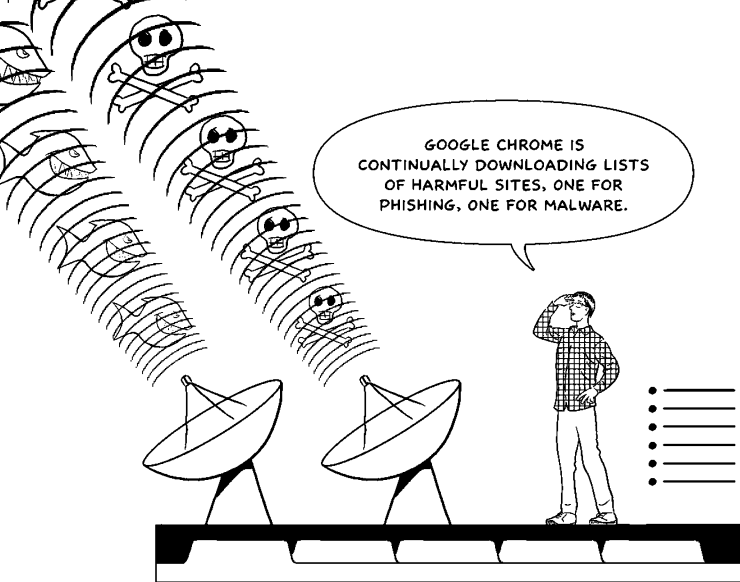
SO I
WORKED ON
RIPPING PLUGINS OUT
OF THE RENDERING
PROCESS AND PUTTING
THEM IN A SEPARATE
PROCESS ALL THEIR
OWN.



IN
THAT WAY,
THE REST OF THE
PAGE CAN STILL BE
SANDBOXED, EVEN
IF THE PLUGIN
CAN'T BE.





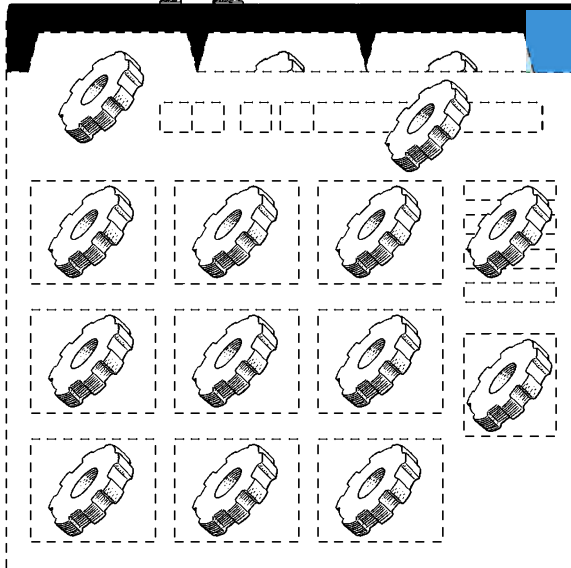




Aaron Boodman,
Software Engineer



ANOTHER THING
WE BUILT INTO
GOOGLE CHROME IS
GEARS.

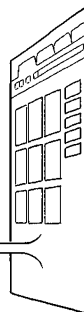
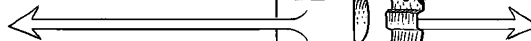


GEARS BASICALLY
ADDS AN API TO
YOUR BROWSER -- AN
EXTENSION THAT
IMPROVES ITS
CAPABILITIES.



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

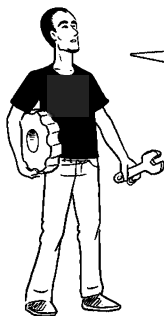
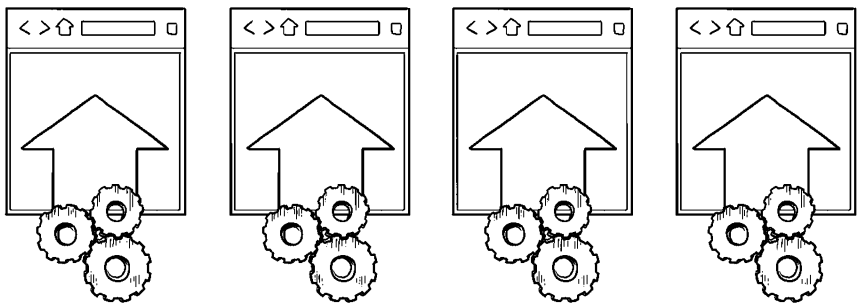
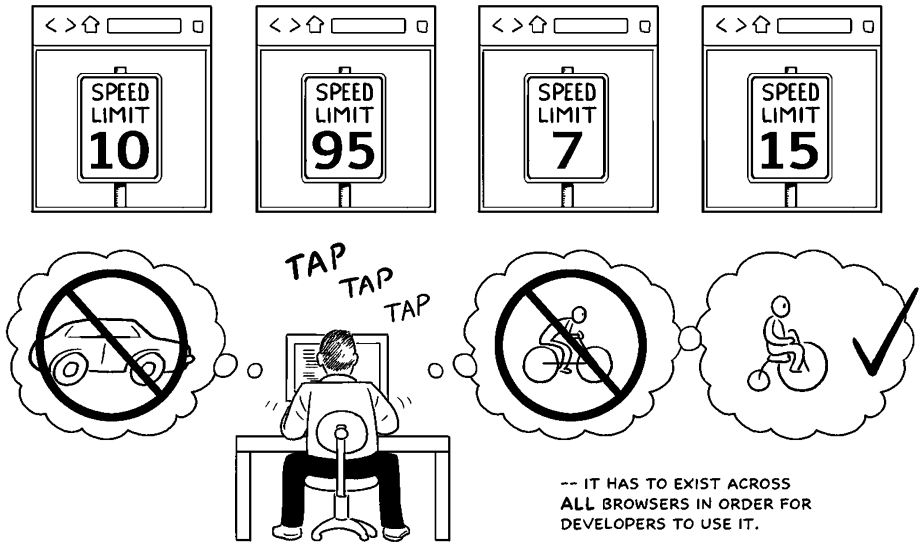
THE BROWSER PROJECT IS
AN EFFORT TO MAKE THE WEB
BETTER FOR **USERS**.



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



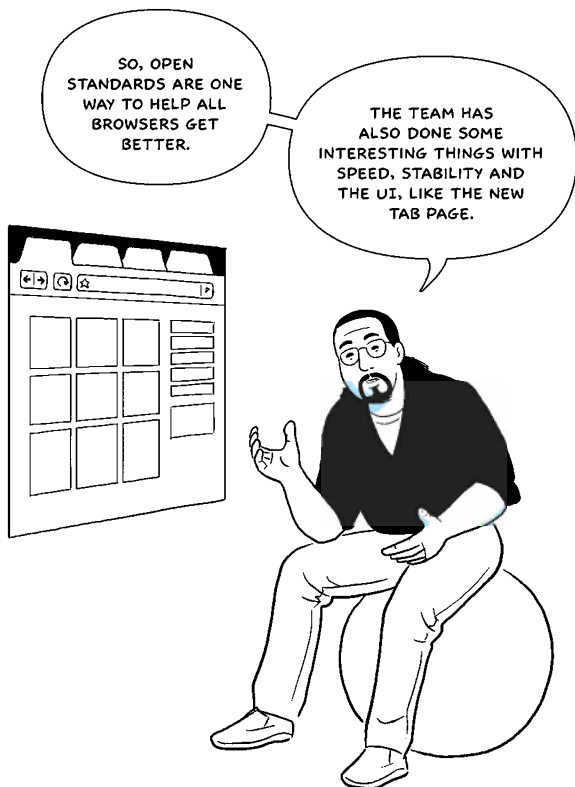
THERE ARE A LOT OF LIMITATIONS TO THE KINDS OF APPLICATIONS THAT YOU CAN BUILD TODAY WITH WEB BROWSERS, AND THE SUBSET OF THINGS YOU CAN DO IS DIFFERENT FOR EACH BROWSER. IF **ONE** BROWSER HAS A COOL FEATURE, THAT DOESN'T HELP --



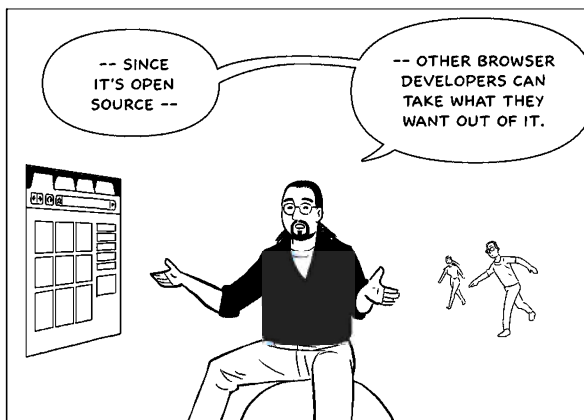
GEARS IS TRYING TO IMPROVE THE BASE FUNCTIONALITY OF ALL BROWSERS, INCLUDING GOOGLE CHROME.

WHATEVER THE ADVANTAGES OF BUILDING NATIVE APPS OVER WEB APPS, WE WANT TO BUILD THOSE ENHANCEMENTS THROUGH GEARS --

-- AND HELP THEM MAKE THEIR WAY INTO NEW STANDARDS ACROSS THE WEB.



Chris DiBona,
Open Source Programs Manager



THEY DON'T HAVE
TO PAY US. THEY
DON'T HAVE TO ASK
OUR PERMISSION.

THEY DON'T HAVE
TO SHARE PATCHES OR
REPORT BUGS.*

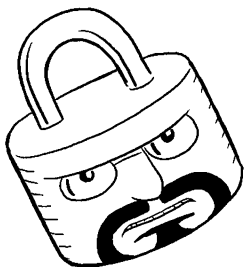


* THOUGH, IF THEY LIKE, WE HAVE
SYSTEMS IN PLACE FOR THAT.

BUT THEY
CAN **BUILD** ON
WHAT WE'VE DONE
AND BRING THEIR
OWN CREATIVITY
TO IT.



SURE, WE
COULD SHIP A
PROPRIETARY
BROWSER AND
HOLD IT IN.



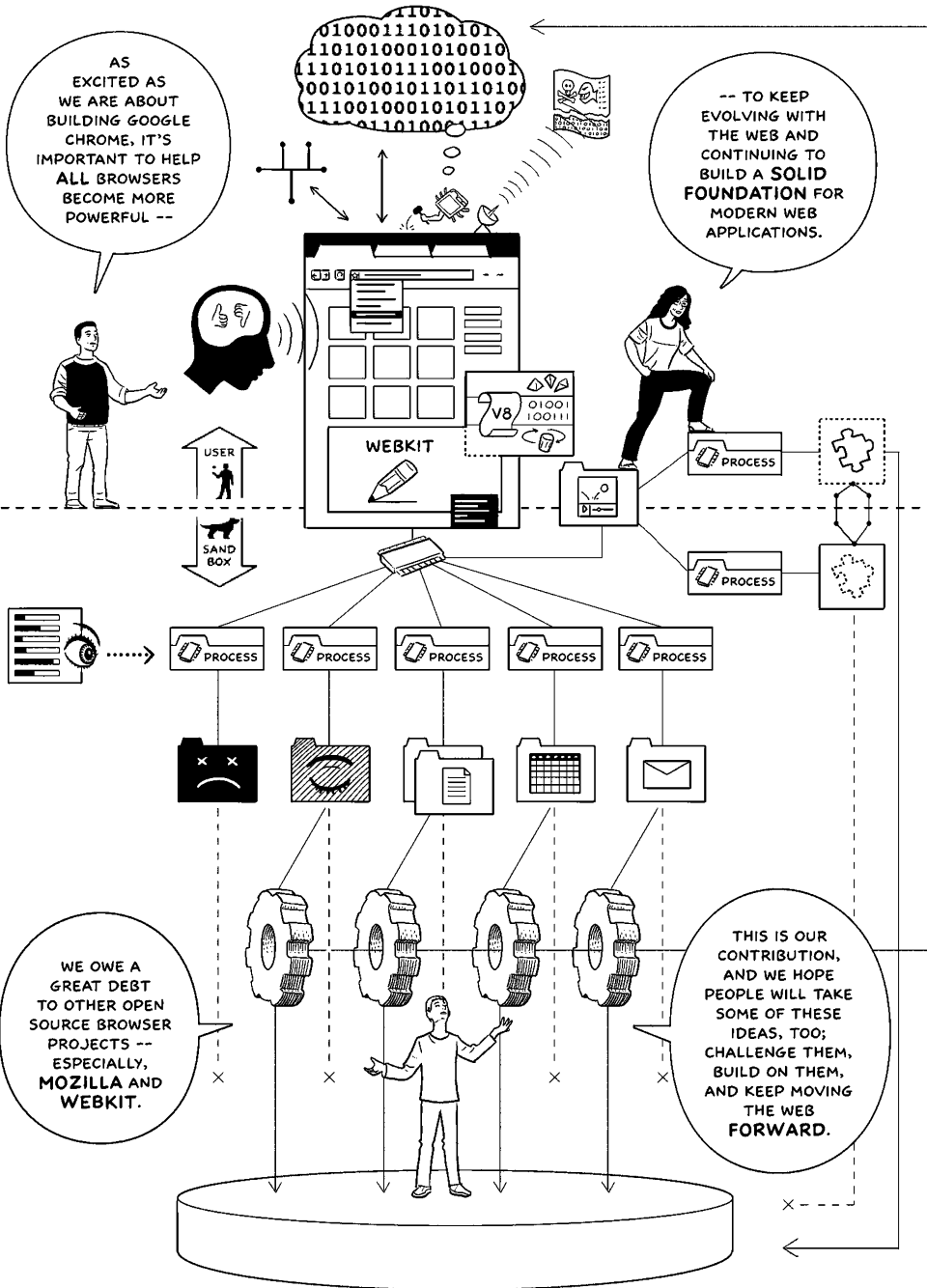
BUT GOOGLE **LIVES**
ON THE INTERNET.

IT'S IN OUR
INTEREST TO MAKE THE
INTERNET BETTER AND
WITHOUT COMPETITION WE
HAVE STAGNATION.



THAT'S WHY
WE'RE OPEN
SOURCING THE
WHOLE THING. WE
NEED THE INTERNET
TO BE A FAIR,
SMART, SAFE
PLACE.





Words

The Google Chrome Team

Comics Adaptation

Scott McCloud

Go gle

www.google.com/chrome

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