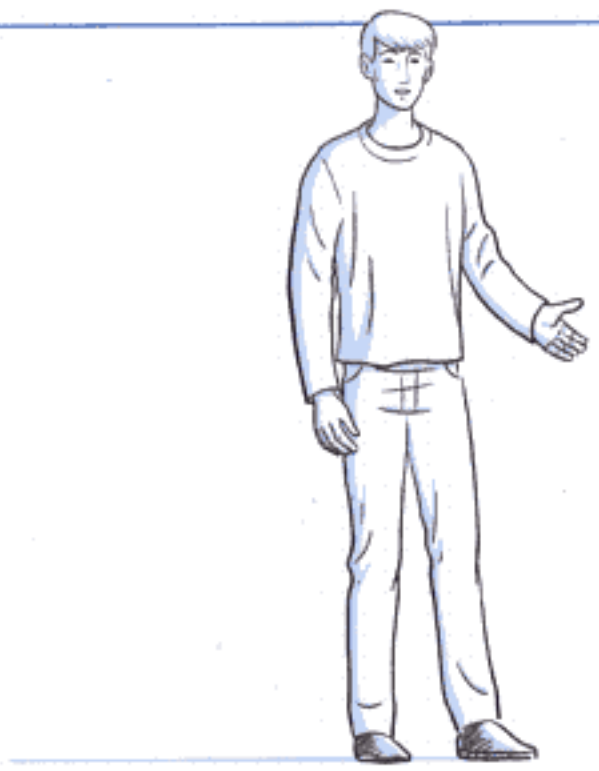
Google Chrome

Google Chrome

Behind the Open Source Browser Project



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

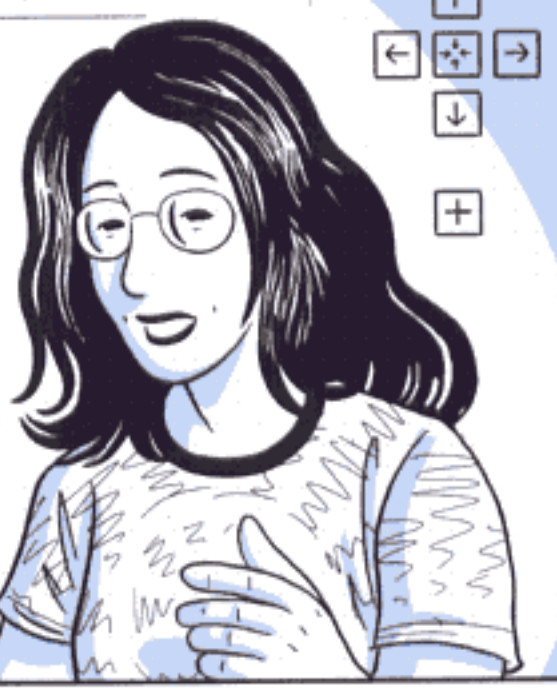
PEOPLE ARE WATCHING AND UPLOADING VIDEOS, CHATTING WITH EACH OTHER, PLAYING WEB-BASED GAMES...

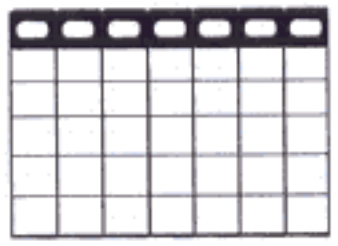
ALL THESE THINGS THAT DIDN'T EXIST WHEN THE FIRST BROWSERS WERE CREATED.

Azula88: ROFL ^^

DctrHrrbl: LOL

Trg: OMFG





Pam Greene, Software Engineer

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

FIRST, BROWSERS NEED TO BE MORE **STABLE**. WHEN YOU'RE WRITING AN IMPORTANT EMAIL OR EDITING A DOCUMENT, A BROWSER CRASH IS A BIG DEAL.

Darin Fisher, Software Engineer

BROWSERS ALSO NEED TO BE **FASTER**. THEY NEED TO START FASTER, LOAD PAGES FASTER --

-- AND FOR WEB APPS, JAVASCRIPT ITSELF CAN BE **A LOT** FASTER.

Lars Bak, Software Engineer

Kasper Lund, Software Engineer

THEY NEED TO BE MORE **SECURE**. GIVEN WHAT'S KNOWN ABOUT MASS BROWSER EXPLOITS, BROWSERS NEED ARCHITECTURAL CHANGES TO DISADVANTAGE MALWARE.

Ian Fette, Product Manager

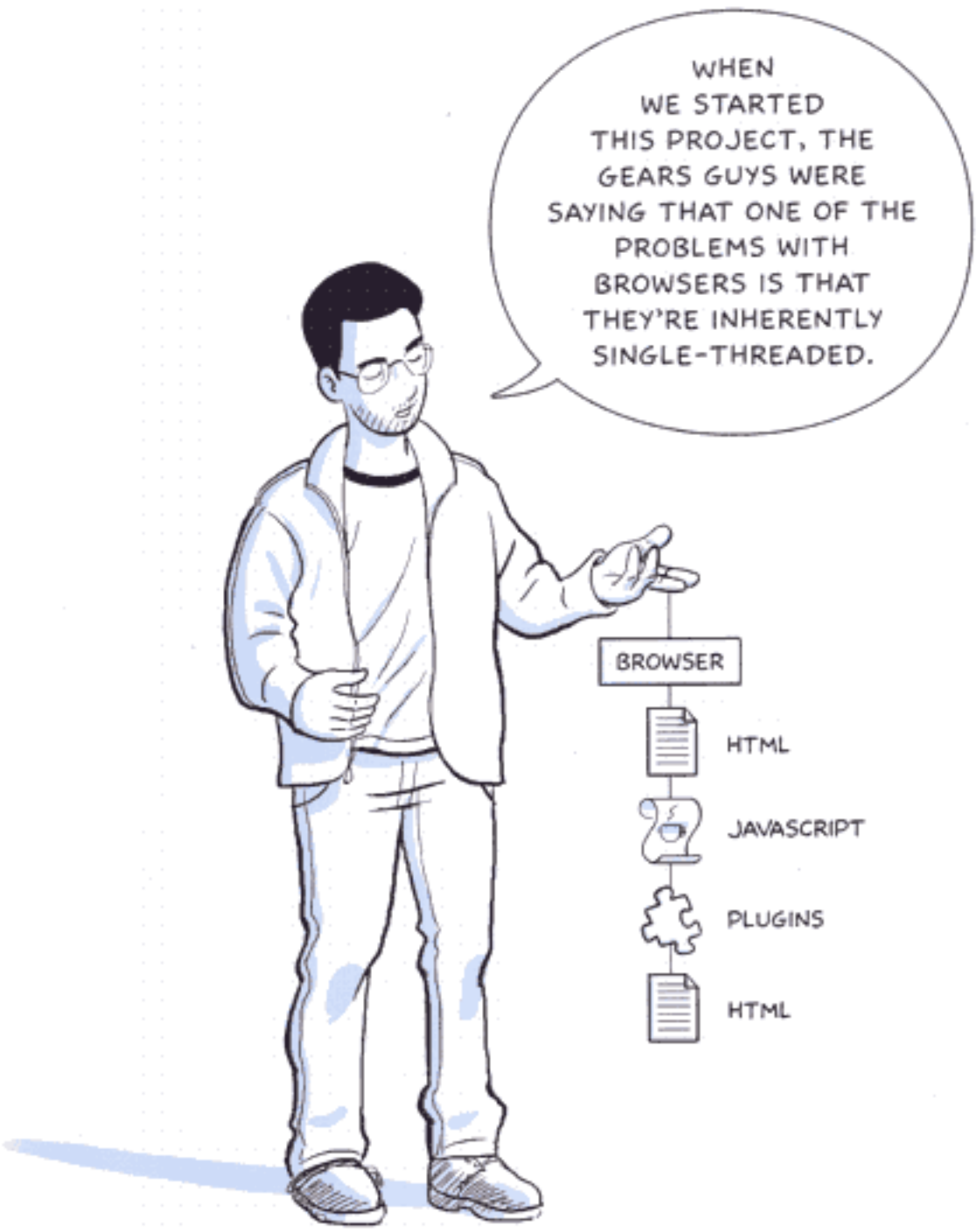
AND WE WANT BROWSERS TO FIND THAT SWEET SPOT BETWEEN TOO MANY FEATURES AND TOO FEW, WITH A **CLEAN, SIMPLE,** AND **EFFICIENT** USER INTERFACE.

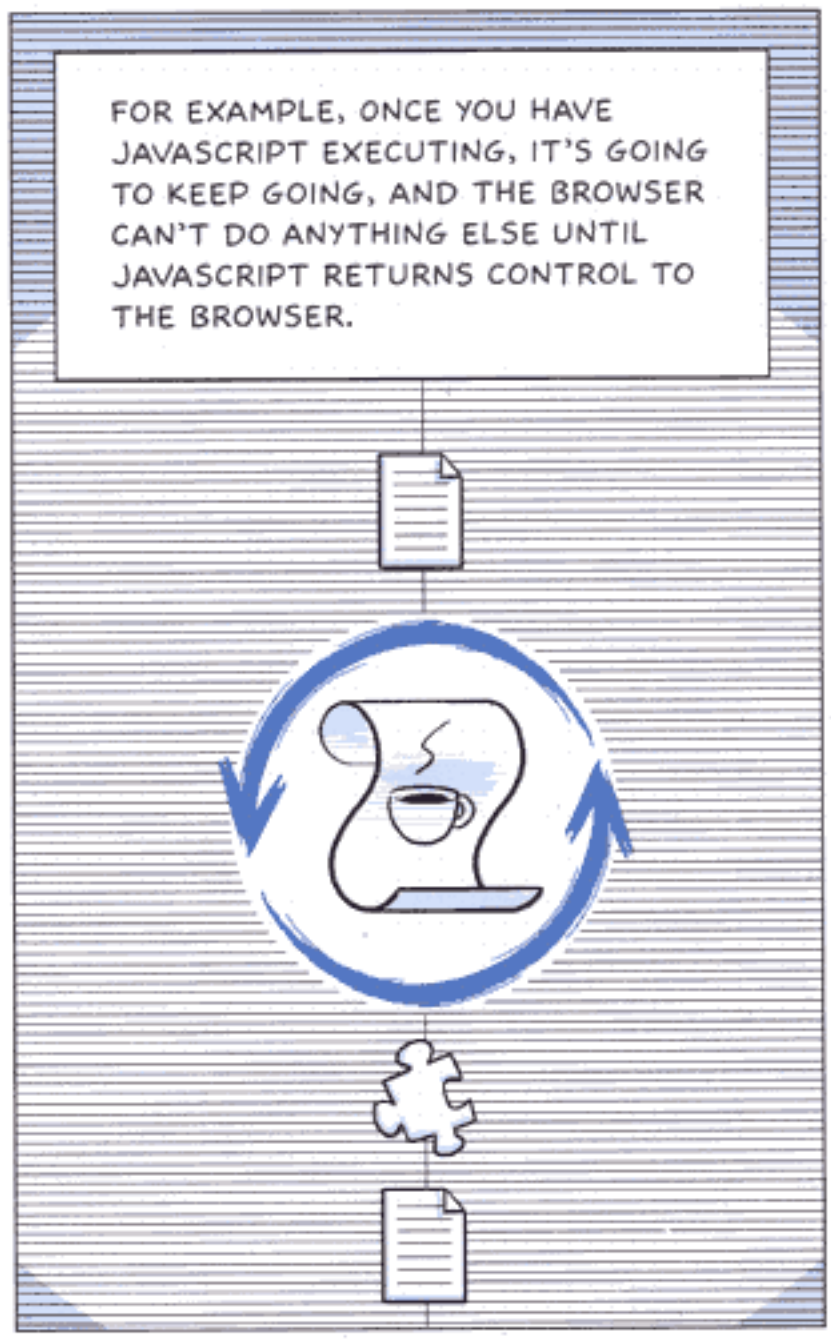
Ben Goodger, Software Engineer

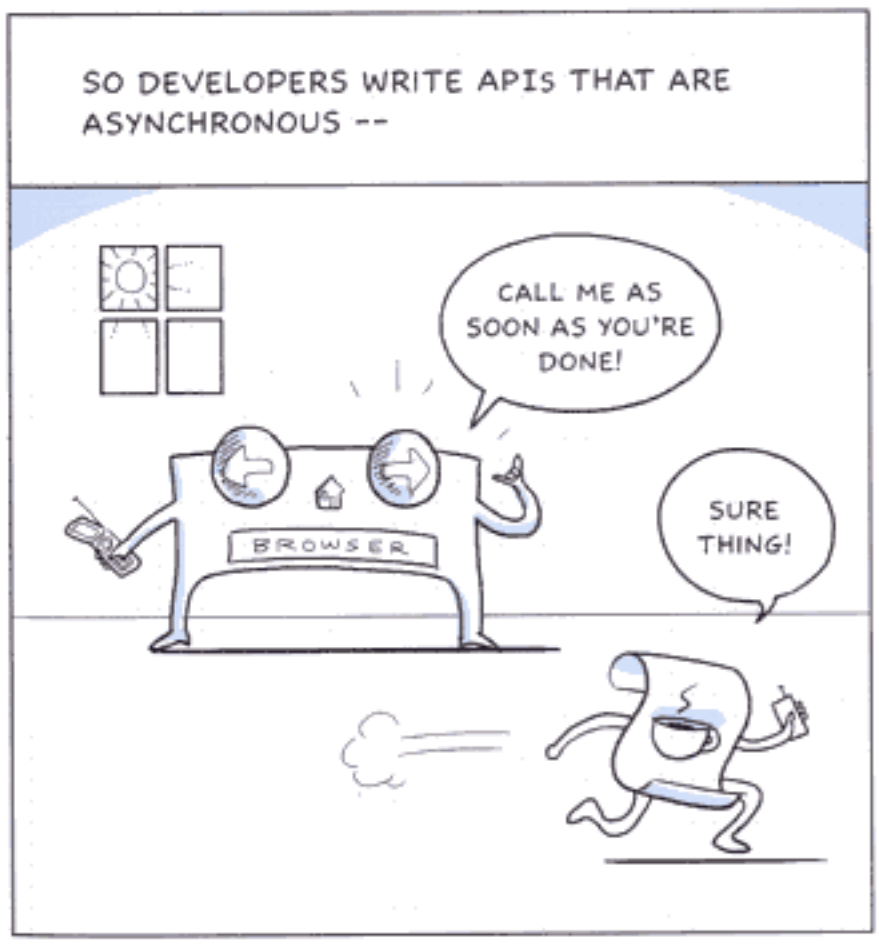
FINALLY, GOOGLE CHROME IS A FULLY **OPEN SOURCE** BROWSER.

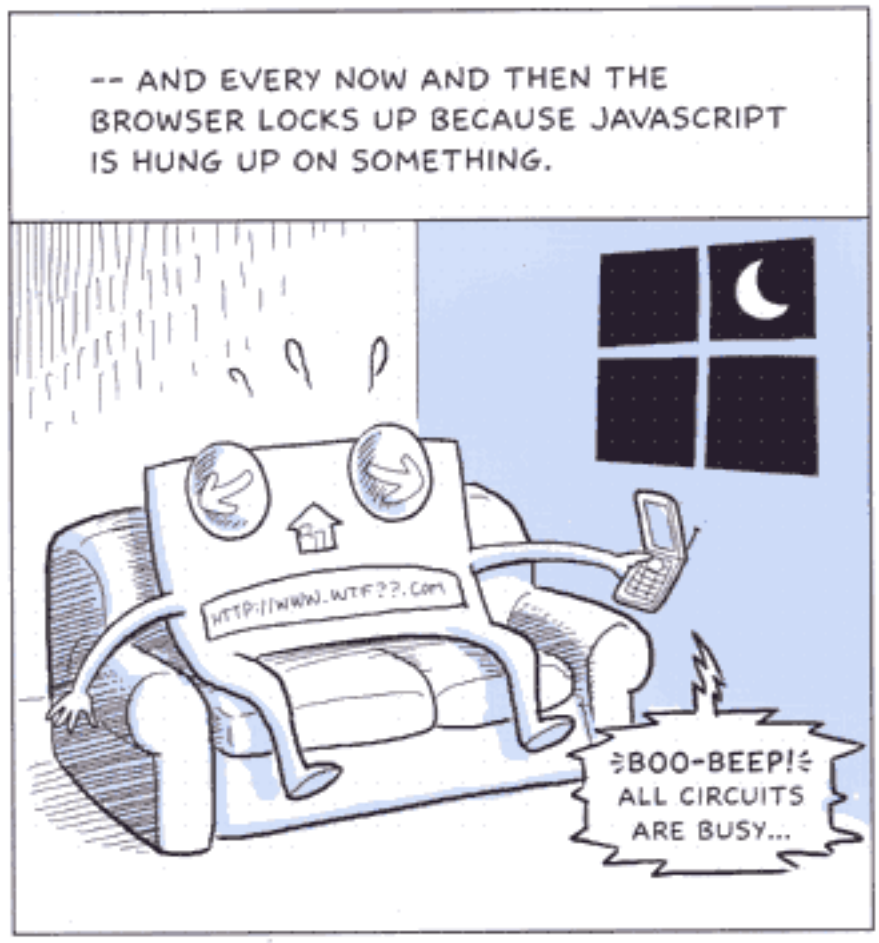
WE WANT OTHERS TO ADOPT IDEAS FROM US --

-- JUST AS WE'VE ADOPTED GOOD IDEAS FROM OTHERS.


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!
BROWSER
SURE THING!


-- AND EVERY NOW AND THEN THE BROWSER LOCKS UP BECAUSE JAVASCRIPT IS HUNG UP ON SOMETHING.
HTTP://WWW.WTF??.COM
BOO-BEEP! ALL CIRCUITS ARE BUSY...

THE GEARS GUYS WERE THINKING ABOUT A MULTI-THREADED BROWSER, BUT THAT LED US TO TALK ABOUT, WELL, INSTEAD OF MULTIPLE THREADS --

BROWSER PROCESS

-- WHAT IF WE HAVE **MULTIPLE PROCESSES**? EACH HAVING ITS OWN MEMORY AND ITS OWN COPY OF THE GLOBAL DATA STRUCTURES.

PROCESS

PROCESS

PROCESS

PROCESS

CHROME PROCESS MANAGER

PROCESS PROCESS PROCESS PROCESS PROCESS PROCESS

Arnaud Weber,
Software Engineer

WE'RE APPLYING THE SAME KIND OF PROCESS ISOLATION YOU FIND IN MODERN OPERATING SYSTEMS.

SO, SEPARATE PROCESSES RENDERING SEPARATE TABS.

PROCESS

PROCESS

AND NOW YOU HAVE SEPARATE JAVASCRIPT THREADS AS WELL.

ONE TAB CAN BE BUSY, WHILE YOU'RE STILL USING ALL THE OTHERS.

AND IF THERE'S A BROWSER BUG IN THE RENDERER (AND OUR EXPERIENCE IS THAT IT'S ALMOST IMPOSSIBLE TO ELIMINATE ALL BUGS), WE STILL ONLY LOSE THE ONE TAB.

WHEN ONE TAB GOES DOWN YOU GET A 'SAD TAB' BUT IT DOESN'T CRASH THE WHOLE BROWSER.

AND YES, IT REALLY LOOKS LIKE THIS.

A MULTI-PROCESS DESIGN MEANS USING A BIT MORE MEMORY UP FRONT. EACH PROCESS HAS A FIXED ADDITIONAL COST.

BUT OVER TIME, IT WILL ALSO MEAN **LESS MEMORY BLOAT.**

CHROME

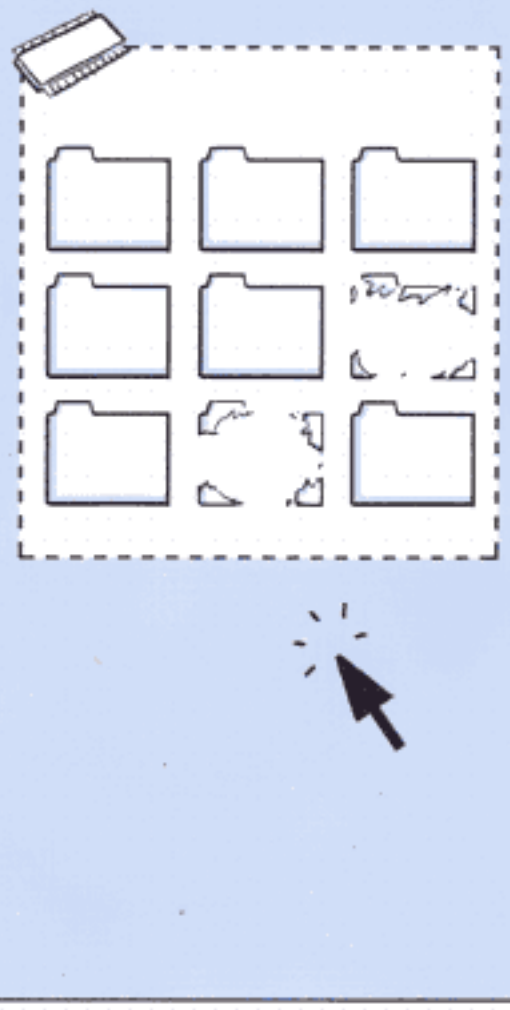
LAUNCH

IN A TRADITIONAL BROWSER, YOU ONLY HAVE ONE PROCESS AND ONE ADDRESS SPACE THAT YOU KEEP LOADING WEB PAGES INTO.

WHEN YOU HAVE TOO MANY TABS OPEN, YOU CAN CLOSE SOME TO FREE UP MEMORY.

WHEN YOU BRING IN ANOTHER TAB, YOU USE THE MEMORY THAT WAS PREVIOUSLY USED.

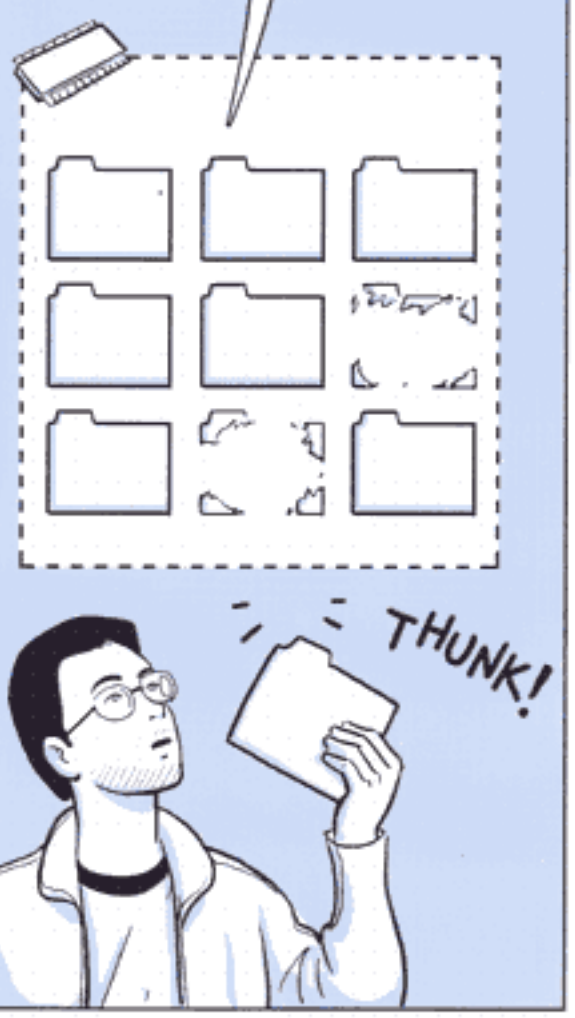
BUT AS TIME GOES ON, FRAGMENTATION RESULTS -- LITTLE BITS OF MEMORY STILL GET USED EVEN WHEN A TAB GETS CLOSED.

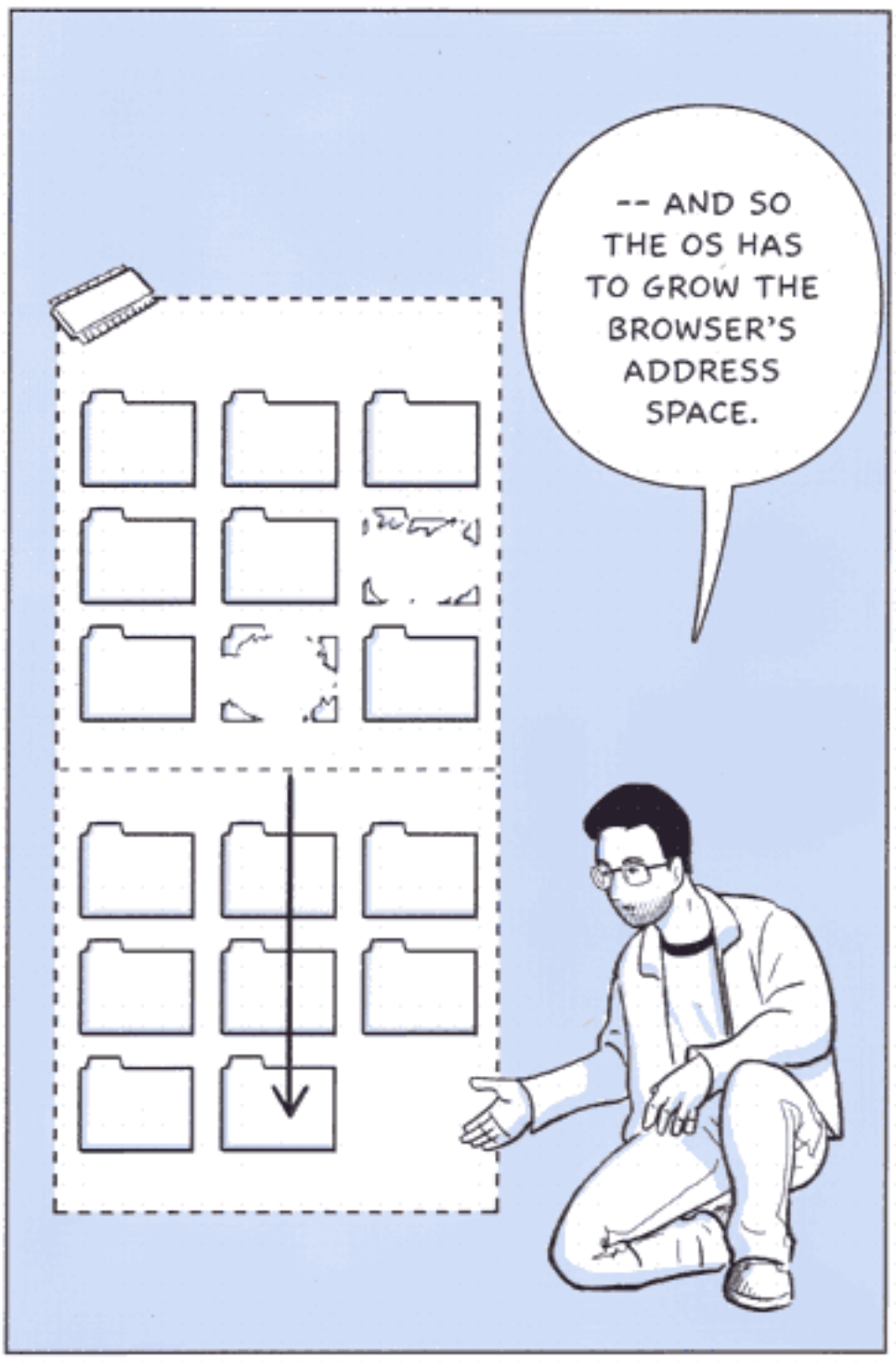


EITHER WE HAVE MEMORY THAT NOTHING CAN REFER TO AGAIN, OR THERE'S A PIECE OF DE-ALLOCATED MEMORY WE STILL HAVE POINTERS TO.

Mike Belshe,
Software Engineer

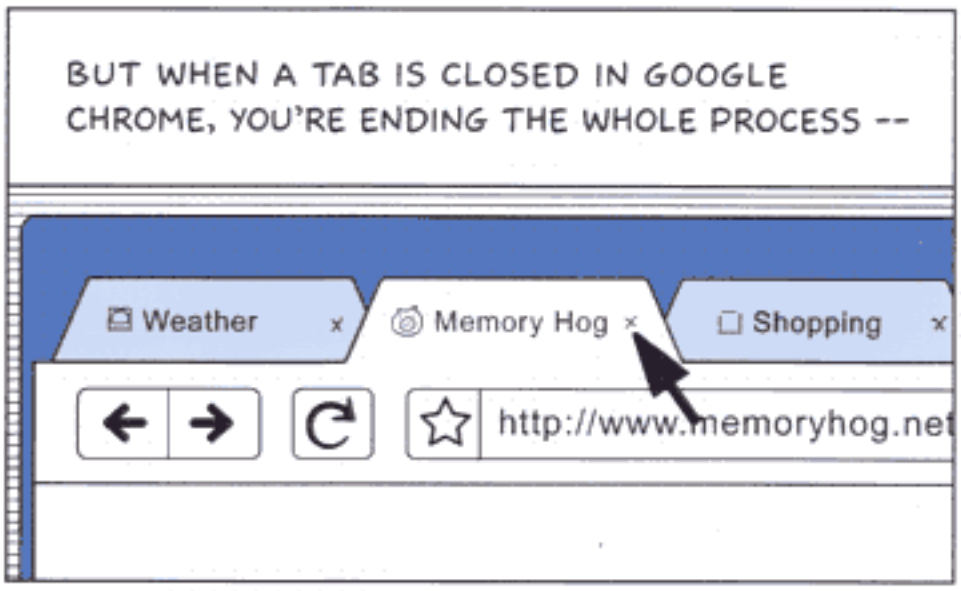
SO WHEN THE BROWSER WANTS TO OPEN A NEW TAB, IT CAN'T FIT IT IN THE EXISTING SPACE --

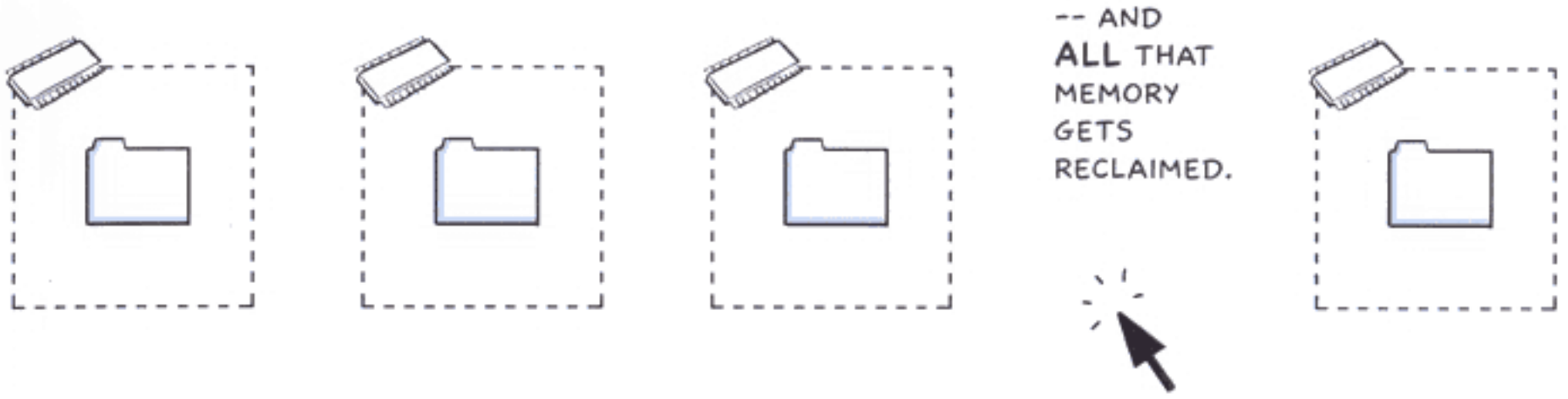


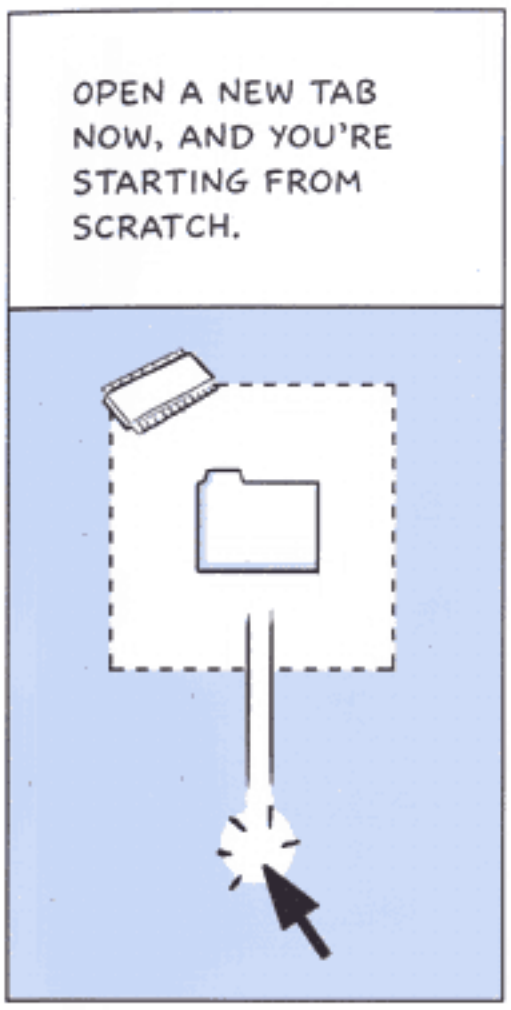


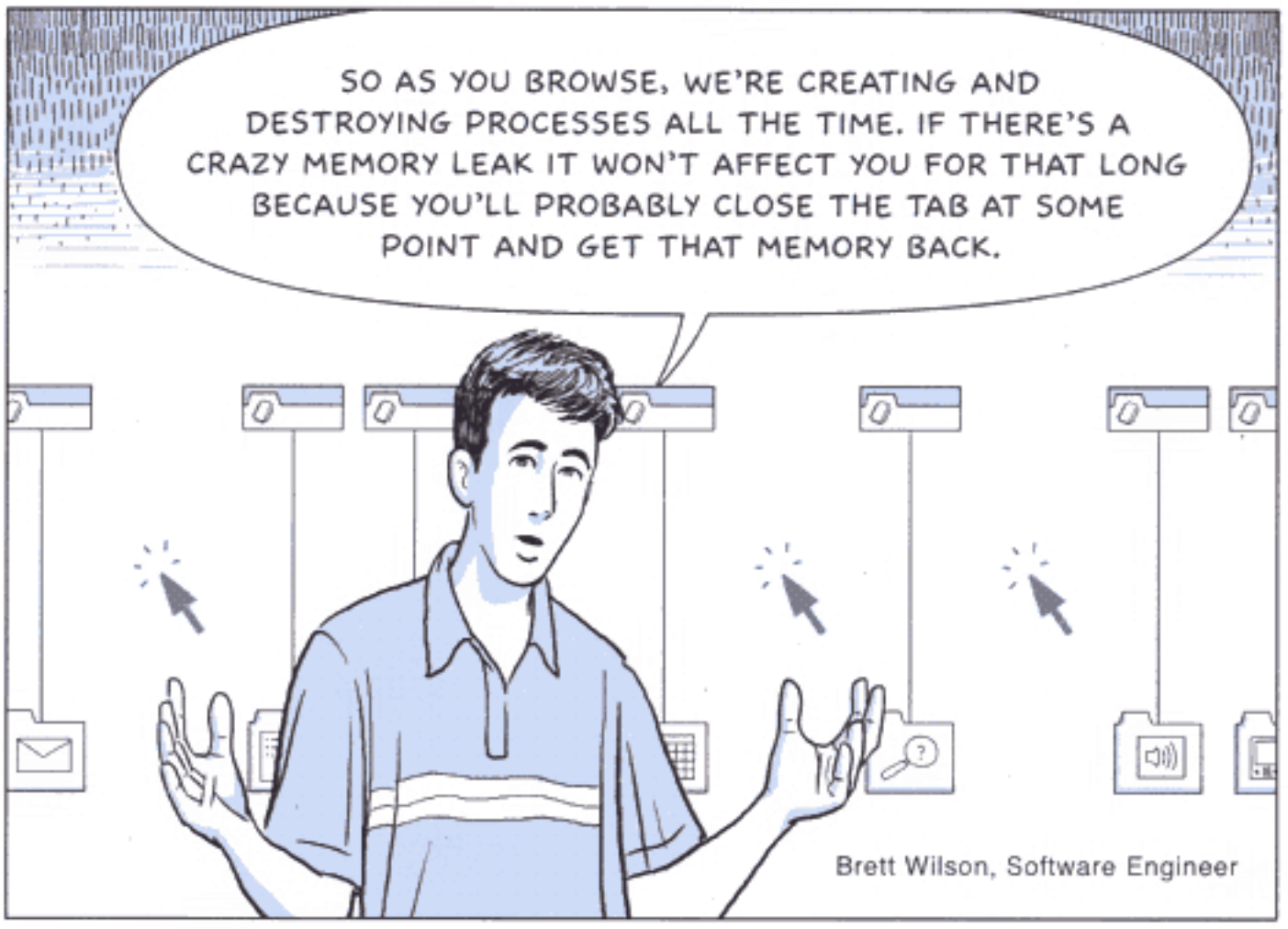
AND THIS PROBLEM GROWS ALL DAY, AS THE LIFETIME OF THE BROWSER EXTENDS.

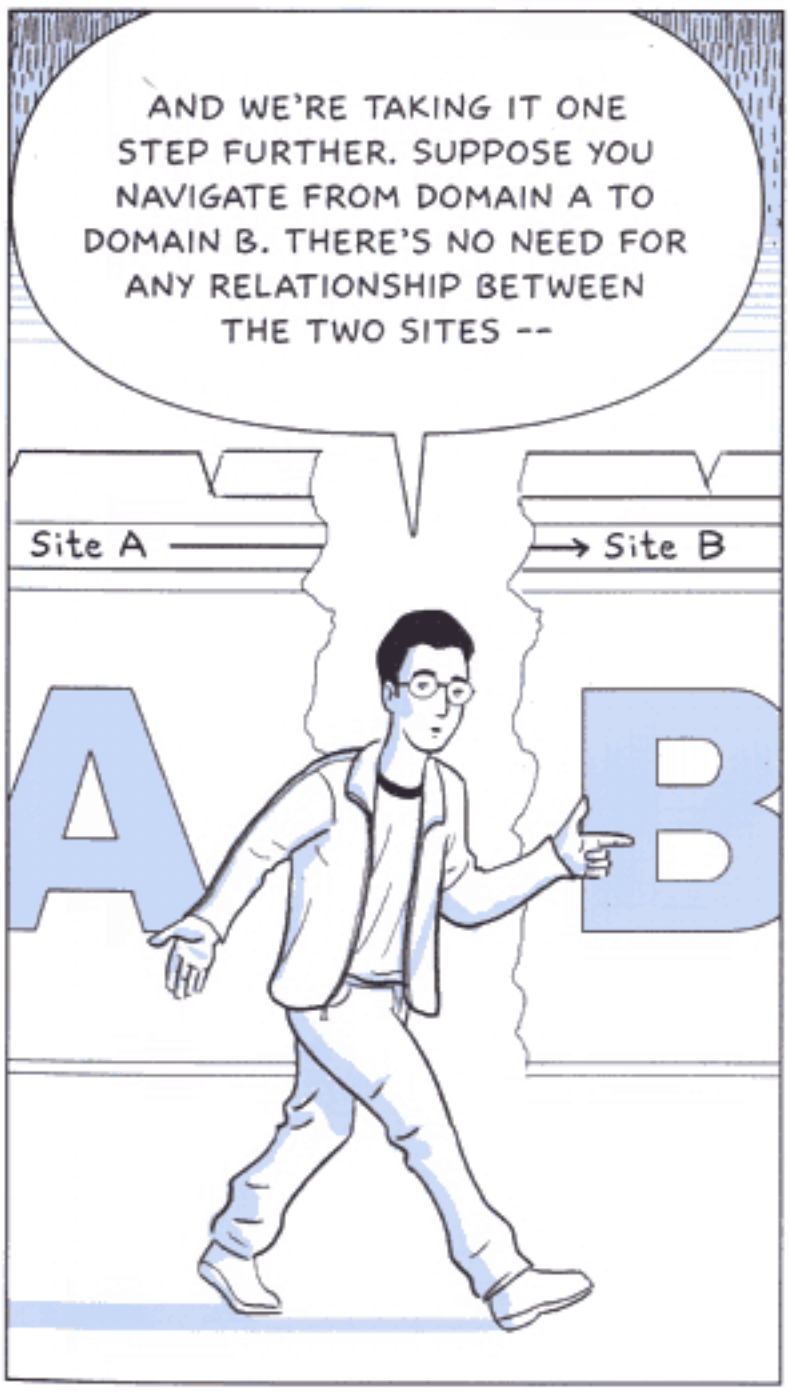
BUT WHEN A TAB IS CLOSED IN GOOGLE CHROME, YOU'RE ENDING THE WHOLE PROCESS --

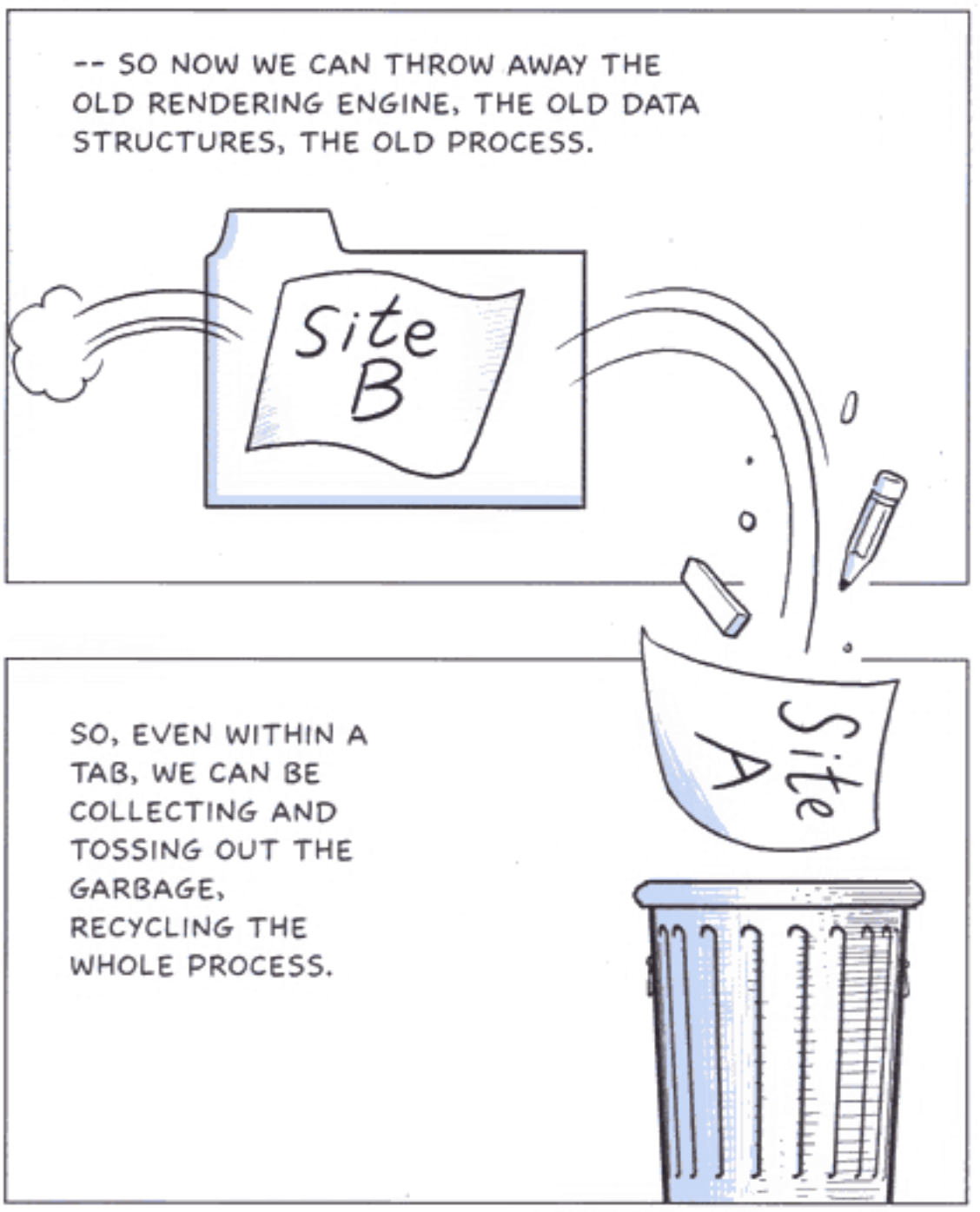



-- AND
ALL THAT
MEMORY
GETS
RECLAIMED.


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 --
Site A
Site B
A
B


-- SO NOW WE CAN THROW AWAY THE OLD RENDERING ENGINE, THE OLD DATA STRUCTURES, THE OLD PROCESS.
Site B
Site A
SO, EVEN WITHIN A TAB, WE CAN BE COLLECTING AND TOSSING OUT THE GARBAGE, RECYCLING THE WHOLE PROCESS.

AND JUST LIKE WITH YOUR OS, YOU CAN LOOK UNDER THE HOOD WITH GOOGLE CHROME'S TASK MANAGER TO SEE WHAT SITES ARE USING THE MOST MEMORY, DOWNLOADING THE MOST BYTES, AND ABUSING YOUR CPU.

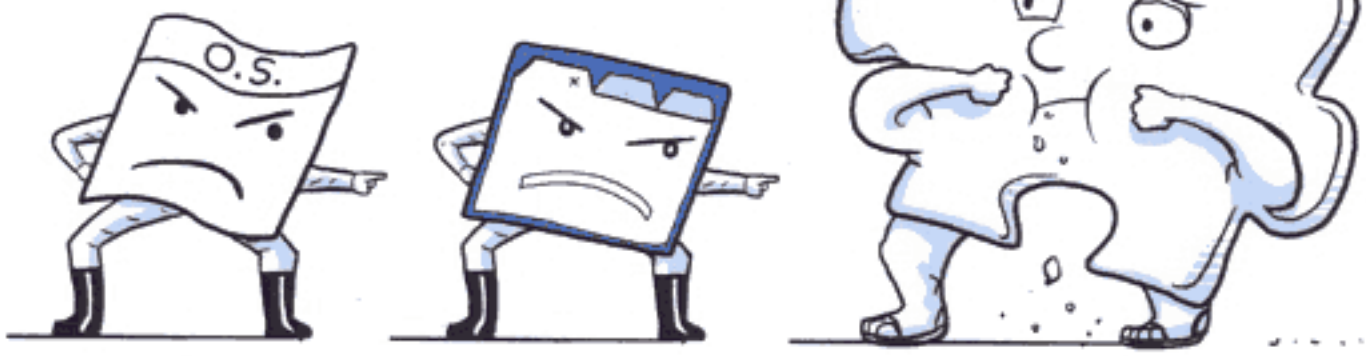
WHY IS THIS APPLICATION DOWNLOADING THE **ENTIRE INTERNET?**

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

YOU CAN EVEN SEE PLUG-INS WITHIN THE TAB, SINCE THEY APPEAR IN CHROME'S TASK MANAGER AS SEPARATE PROCESSES.

	Memory	CPU	Network
	74,000K	0	0
n Mail		0	0
n	14,768K	0	0
		0	0
ems	17,200K	1	0

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



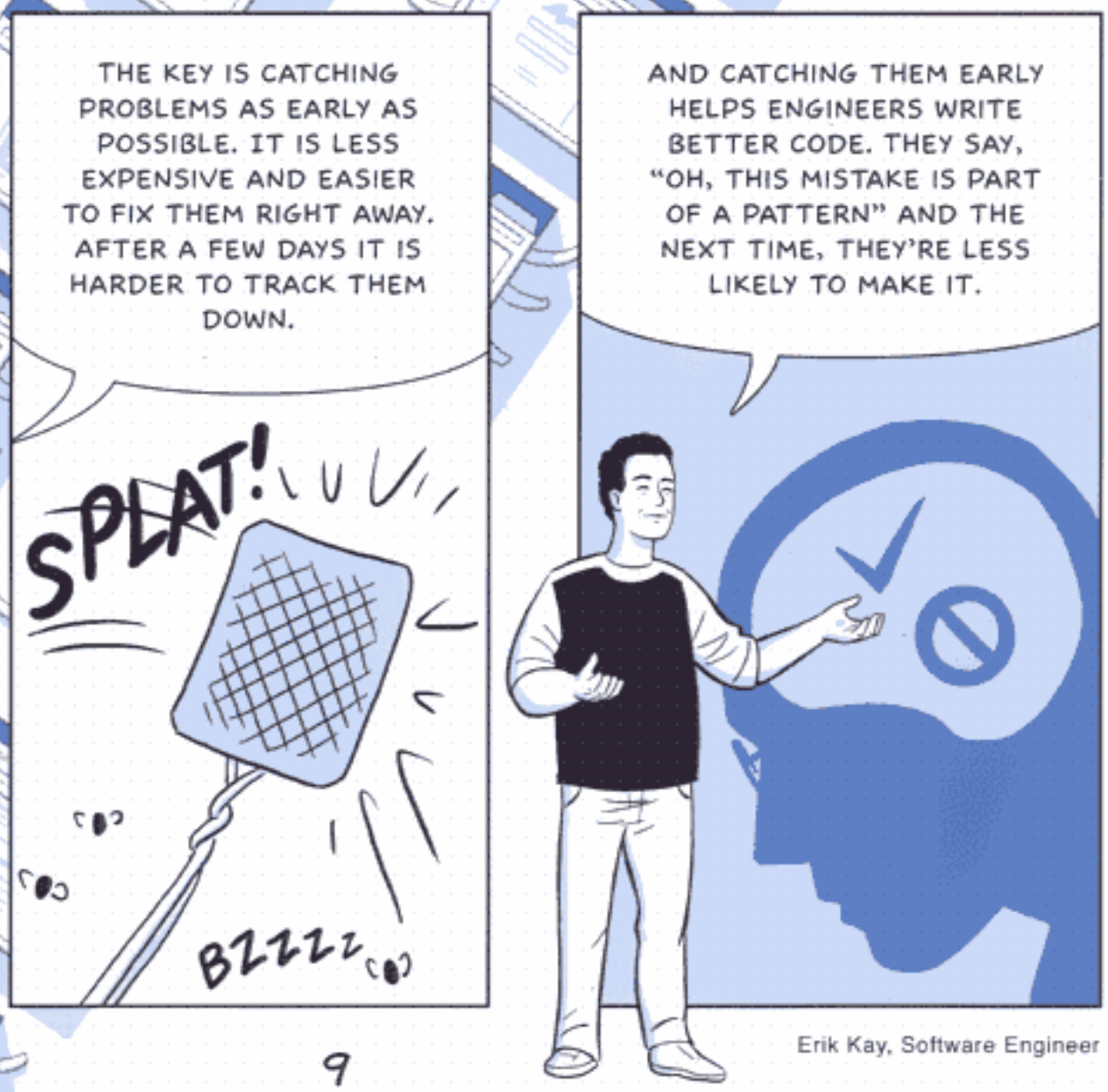
-- AND **ELIMINATE 'EM.**

SNAP!

PLACING BLAME WHERE BLAME **BELONGS.**

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.

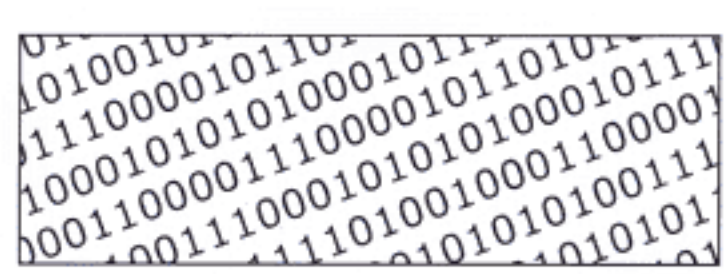


ONE BILLION

OF COURSE, THERE ARE BILLIONS, MAYBE TRILLIONS OF WEBPAGES OUT THERE. IF EACH BUILD IS TESTED AGAINST A MILLION SITES, **WHICH** MILLION DO WE USE?

ONE MILLION

FORTUNATELY, WE HAVE A UNIQUE TAKE ON THIS PROBLEM ALSO.

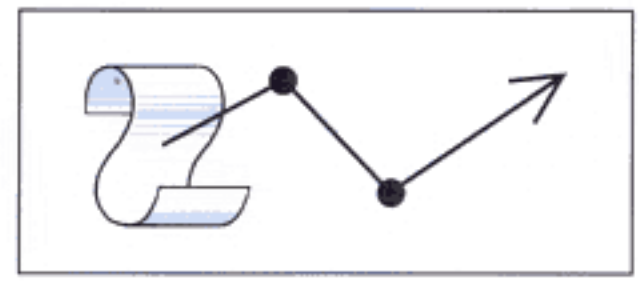


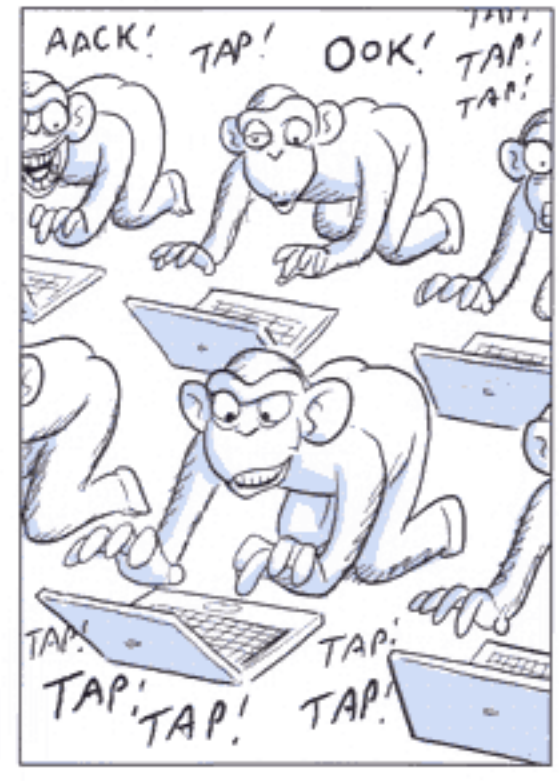
THERE ARE SEVERAL WAYS WE TEST EACH CHECK-IN. FROM UNIT TESTS OF INDIVIDUAL PIECES OF CODE --

-- TO AUTOMATED UI TESTING OF SCRIPTED USER ACTIONS LIKE "CLICKED BACK BUTTON... WENT TO PAGE..." --

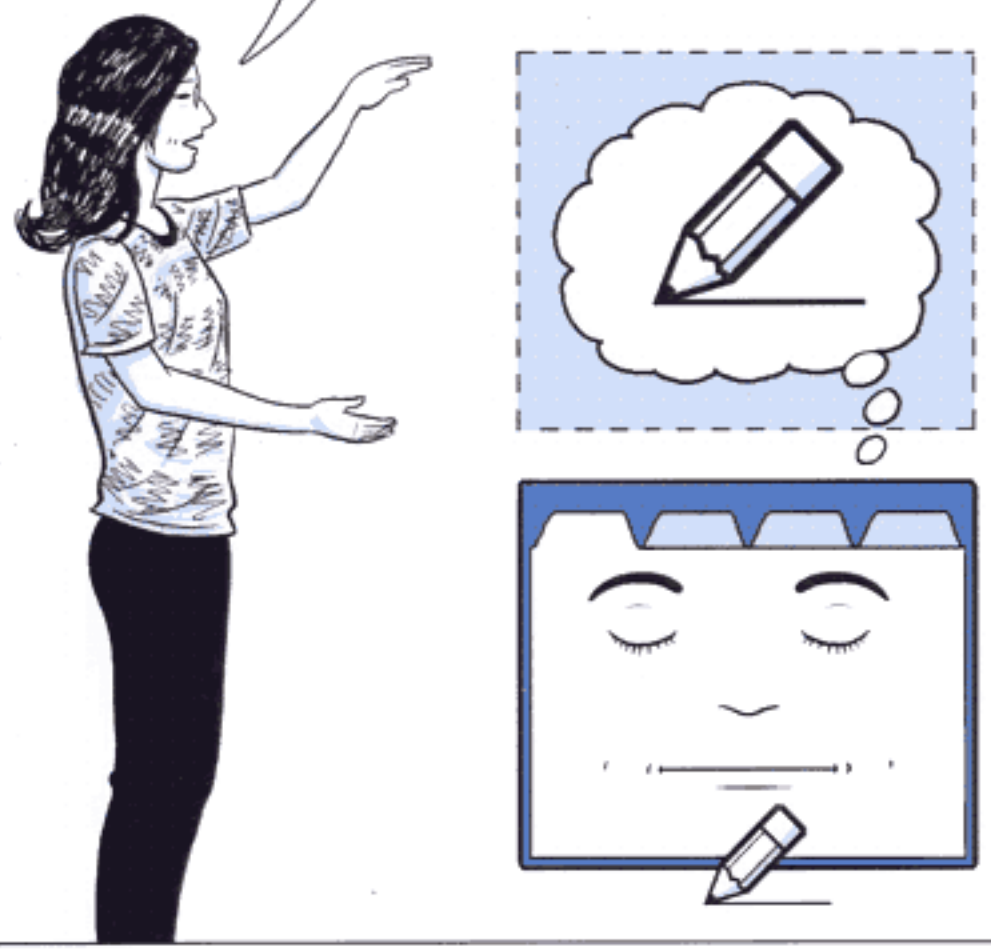
-- TO FUZZ TESTING: SENDING YOUR APPLICATION RANDOM INPUT.

Pam Greene, Software Engineer

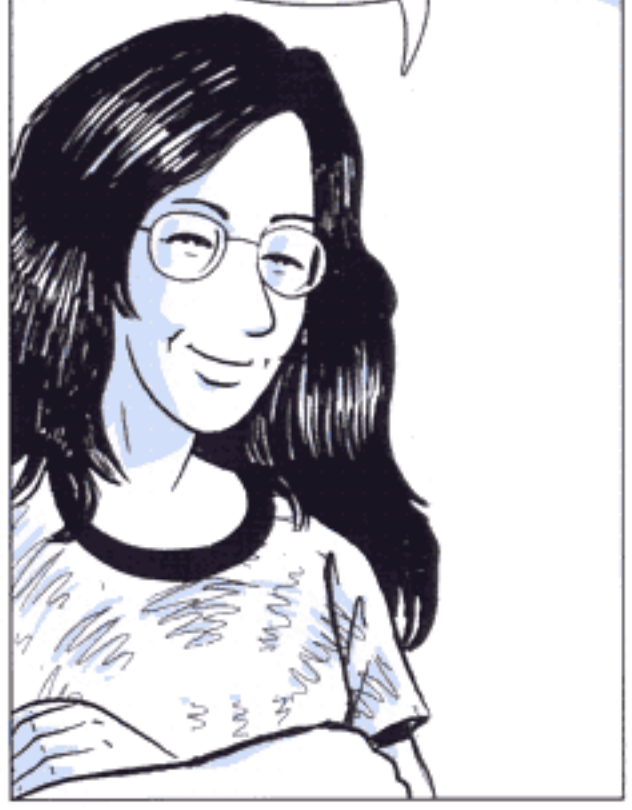




IN LAYOUT TESTING, WEBKIT FOUND THAT PRODUCING A SCHEMATIC OF WHAT THE BROWSER **THINKS** IT'S DISPLAYING IS A MORE PRECISE WAY TO COMPARE LAYOUTS THAN TAKING SCREENSHOTS AND CREATING A CRYPTOGRAPHIC HASH.



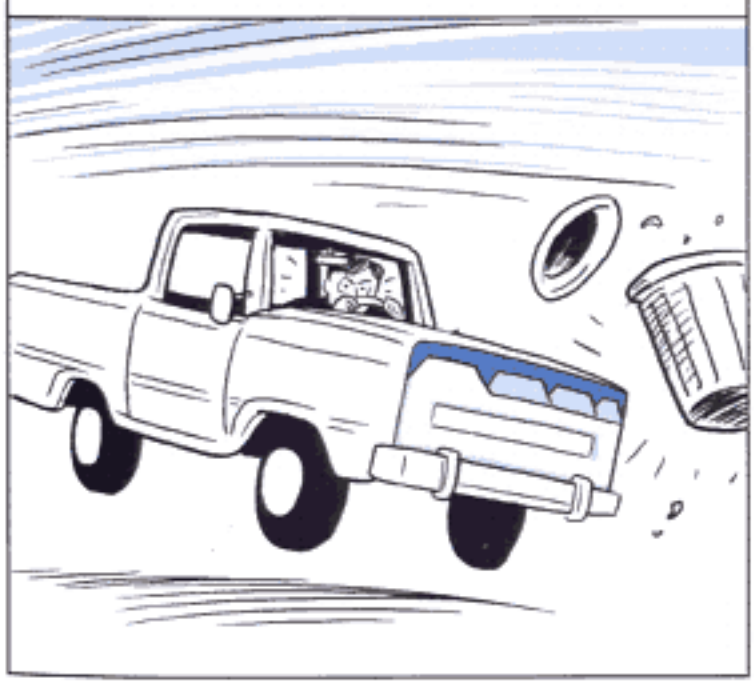
WHEN WE STARTED WE WERE PASSING 23% OF WEBKIT'S LAYOUT TESTS. MOVING FROM THERE TO 99% HAS BEEN A FUN CHALLENGE AND AN INTERESTING EXAMPLE OF TEST-DRIVEN DESIGN.



THERE ARE LIMITS TO WHAT WE CAN DO WITH AUTOMATED TESTING.

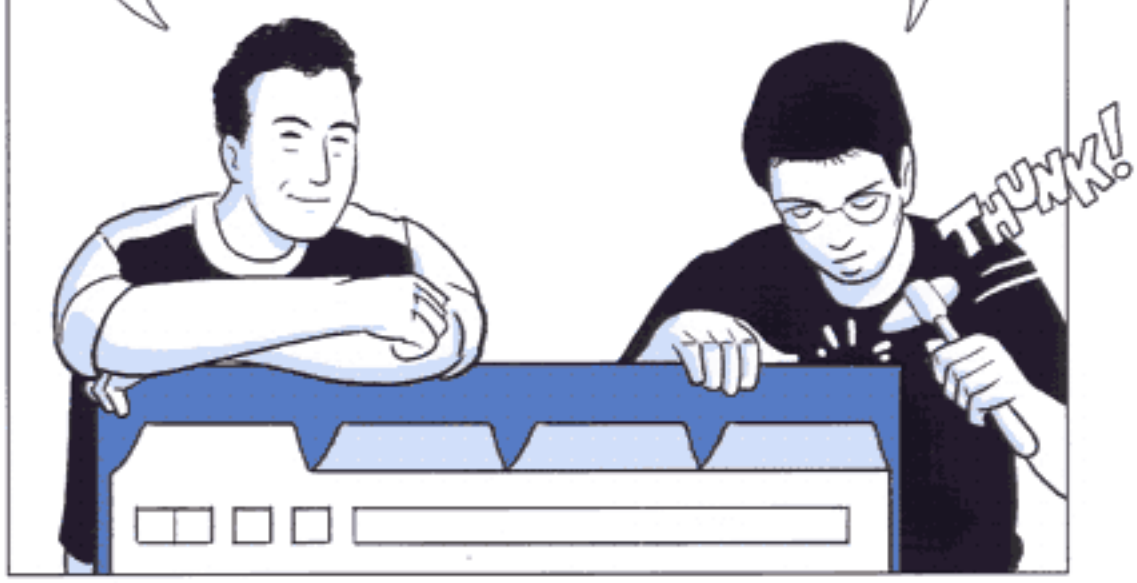
WE CAN'T TEST WEBSITES THAT REQUIRE A PASSWORD, FOR EXAMPLE.

AND IT'S NOT THE SAME AS A HUMAN BEING WALKING AROUND AND MISUSING THINGS. WE ARE USING THE BROWSER IN THE WAY WE'VE DESIGNED IT TO BE USED.



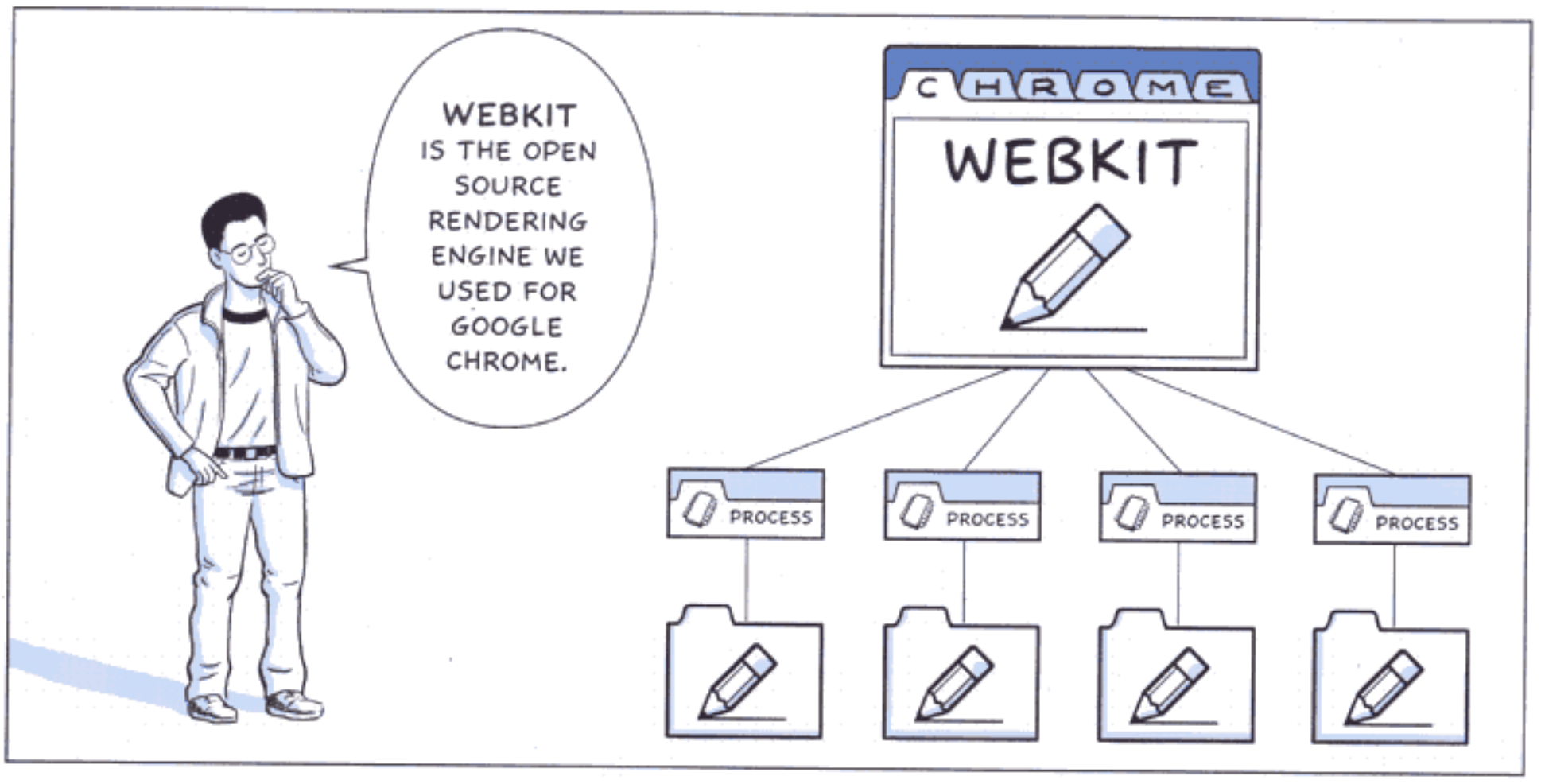
IT'S HARD TO COVER 100%, BUT THAT'S WHAT WE'RE TRYING TO DO.

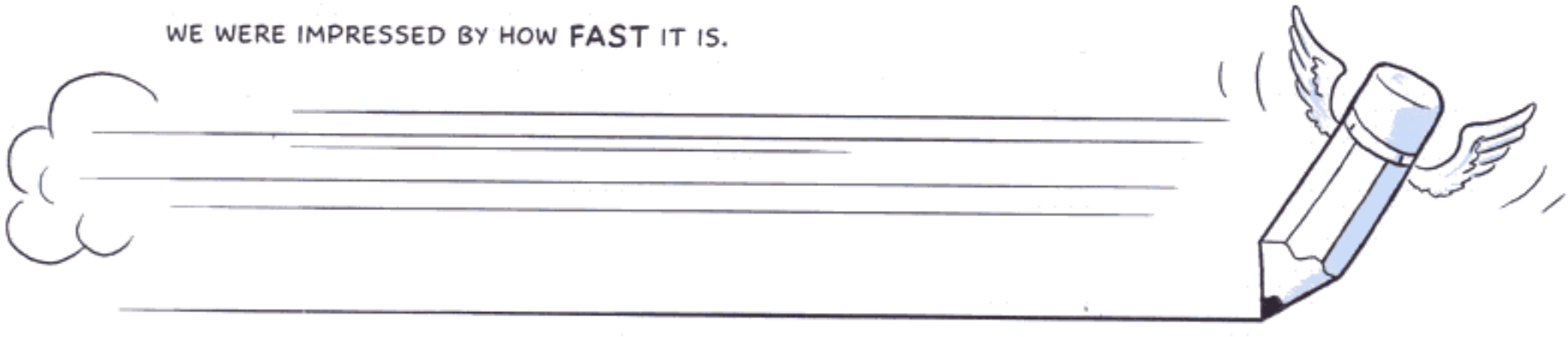
I DON'T CARE IF THERE'S ONE FEWER COOL FEATURE. I JUST WANT THIS PRODUCT TO BE **ROCK SOLID.**

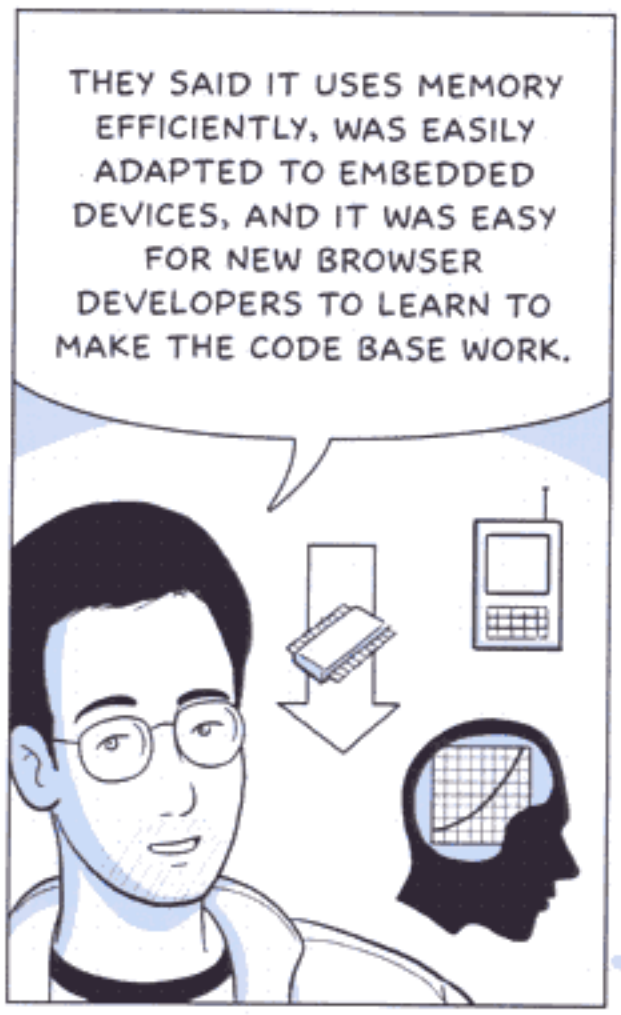


Part Two

Speed: WebKit and V8





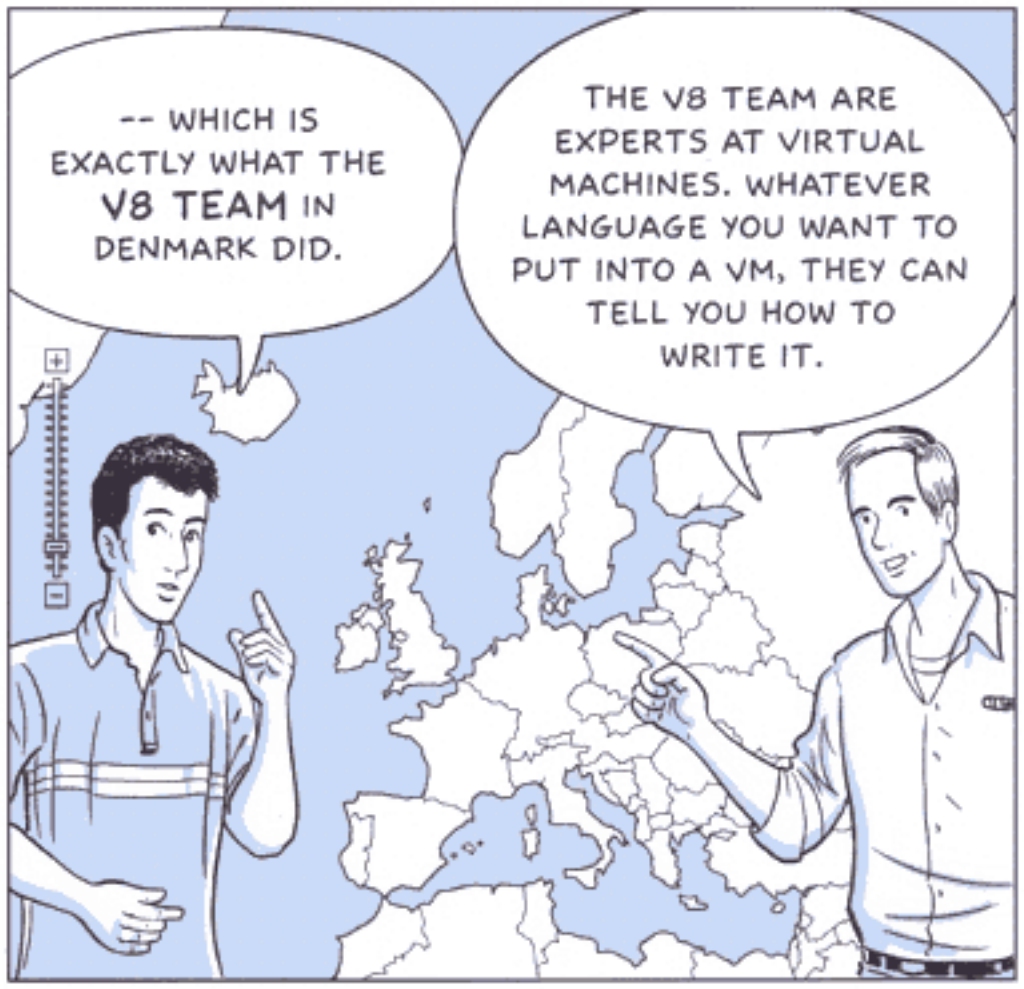


BECAUSE **JAVASCRIPT** IS SO IMPORTANT TO THE WEB TODAY --

-- WE DECIDED IT WAS IMPORTANT TO WORK ON BUILDING A JAVASCRIPT **VIRTUAL MACHINE** --

-- WHICH IS EXACTLY WHAT THE **V8 TEAM** IN DENMARK DID.

THE V8 TEAM ARE EXPERTS AT VIRTUAL MACHINES. WHATEVER LANGUAGE YOU WANT TO PUT INTO A VM, THEY CAN TELL YOU HOW TO WRITE IT.



VIRTUAL MACHINES PROVIDE SAFETY AND PLATFORM INDEPENDENCE.

Lars Bak, Software Engineer, V8

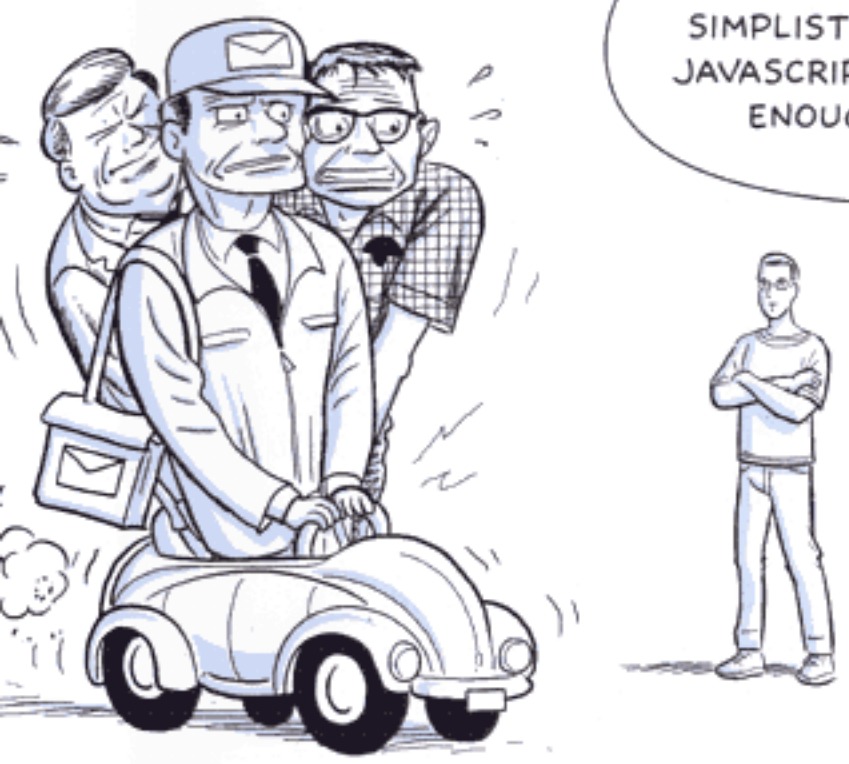
BUT PREVIOUS VIRTUAL MACHINES FOR JAVASCRIPT WERE DESIGNED FOR SMALL PROGRAMS, WHERE THE PERFORMANCE AND INTERACTIVITY OF THE SYSTEM WEREN'T THAT IMPORTANT.

Kasper Lund, Software Engineer, V8

THEY JUST WANTED TO RUN SOME VERY BASIC STUFF ON A WEBPAGE.

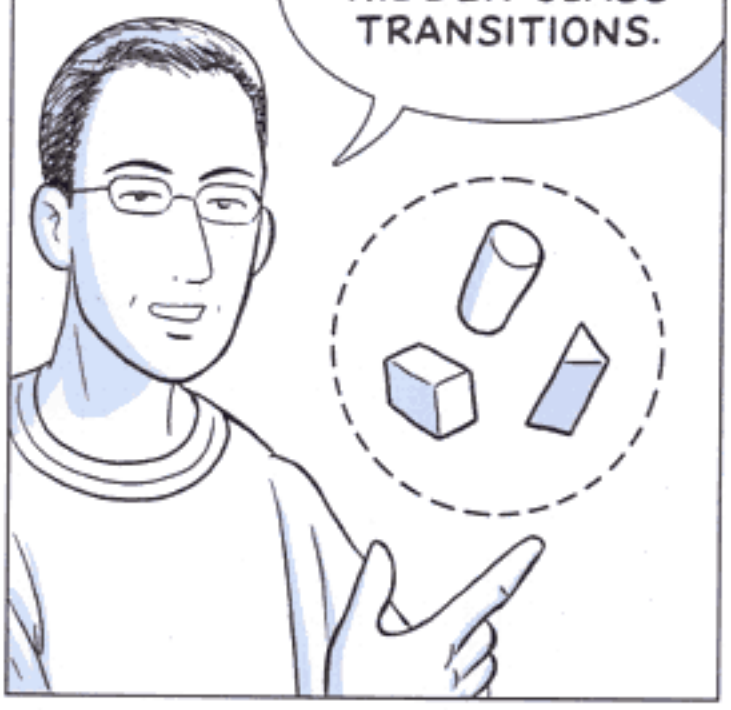
BUT NOW,
YOU HAVE WEB APPLICATIONS LIKE GMAIL THAT ARE USING THE WEB BROWSER TO ITS FULLEST WHEN IT COMES TO DOM MANIPULATIONS AND JAVASCRIPT --

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

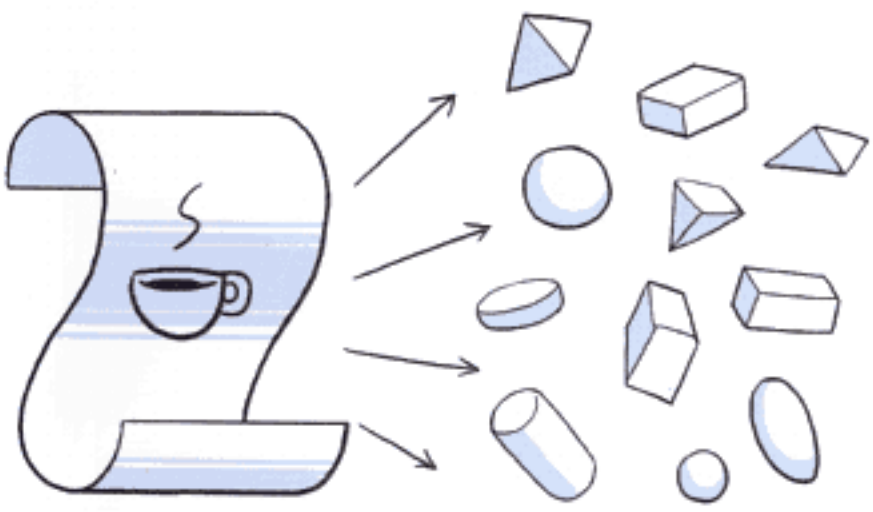


SO WE STARTED WITH NO CODE, JUST SOME WILD IDEAS ABOUT HOW TO MAKE IT GO REALLY FAST --

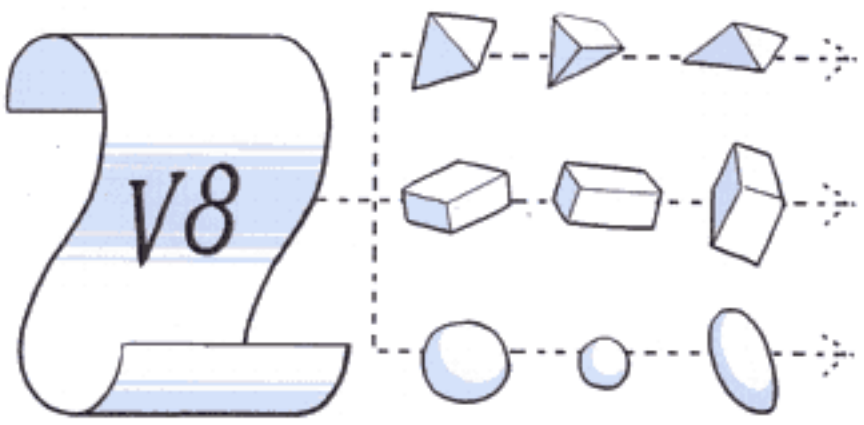
-- SUCH AS INTRODUCING **HIDDEN CLASS TRANSITIONS.**



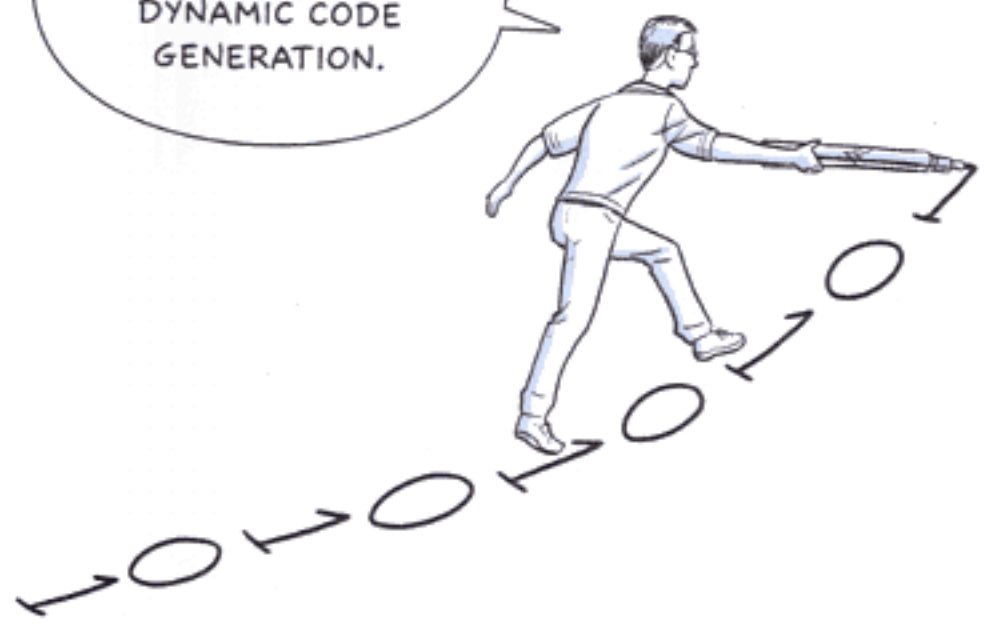
JAVASCRIPT ITSELF IS **CLASSLESS.** YOU CAN CREATE A NEW OBJECT, DYNAMICALLY ADD PROPERTIES TO IT AND GO ON.



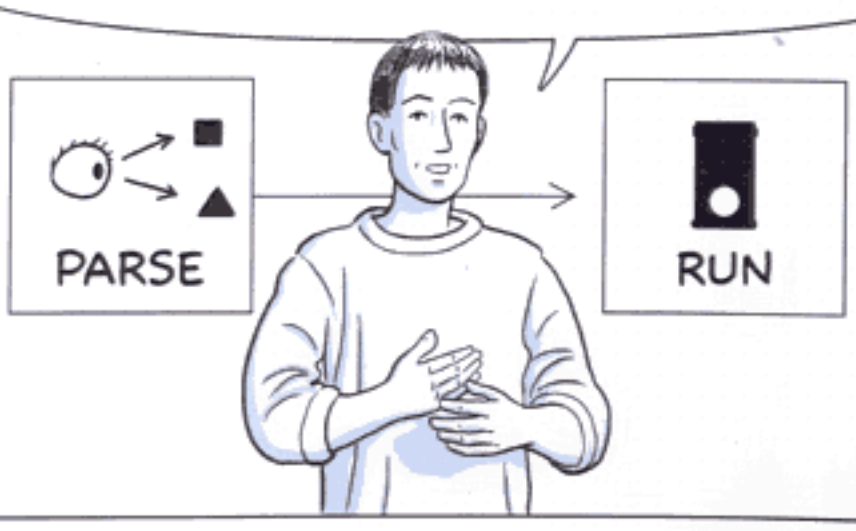
BUT IN **V8**, AS EXECUTION GOES ON, OBJECTS THAT END UP WITH THE SAME PROPERTIES WILL SHARE THE SAME HIDDEN CLASS AND WE CAN START APPLYING DYNAMIC OPTIMIZATIONS BASED ON THAT.

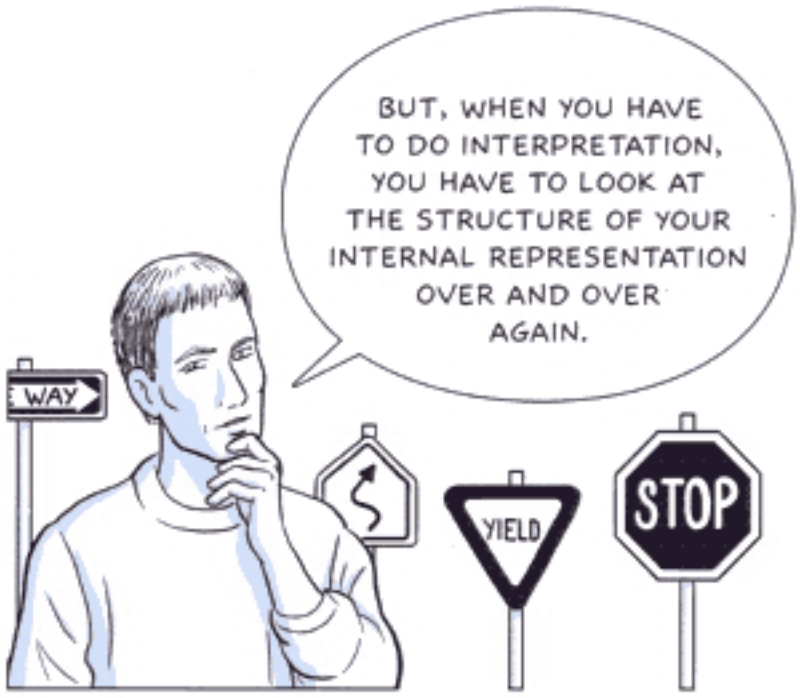


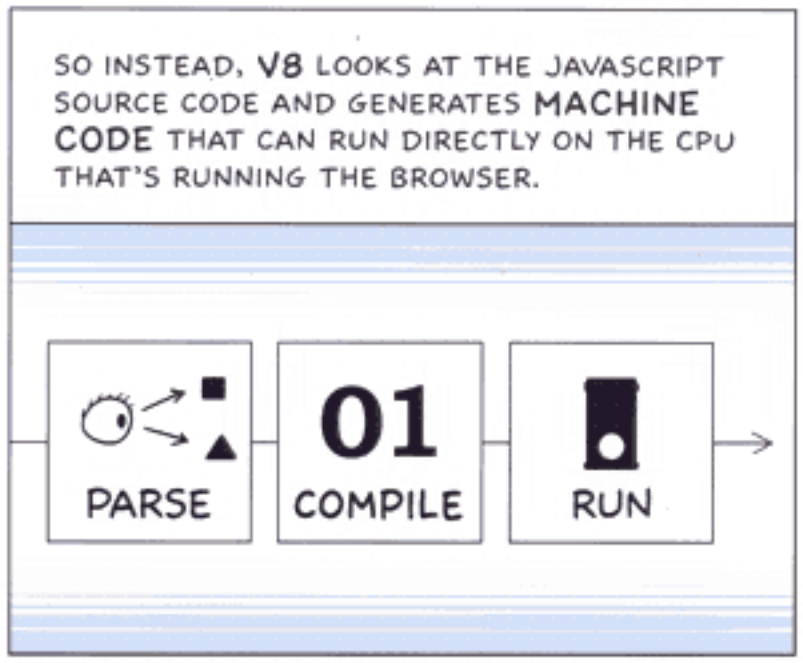
ANOTHER FACTOR IN V8'S SPEED IS DYNAMIC CODE GENERATION.



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

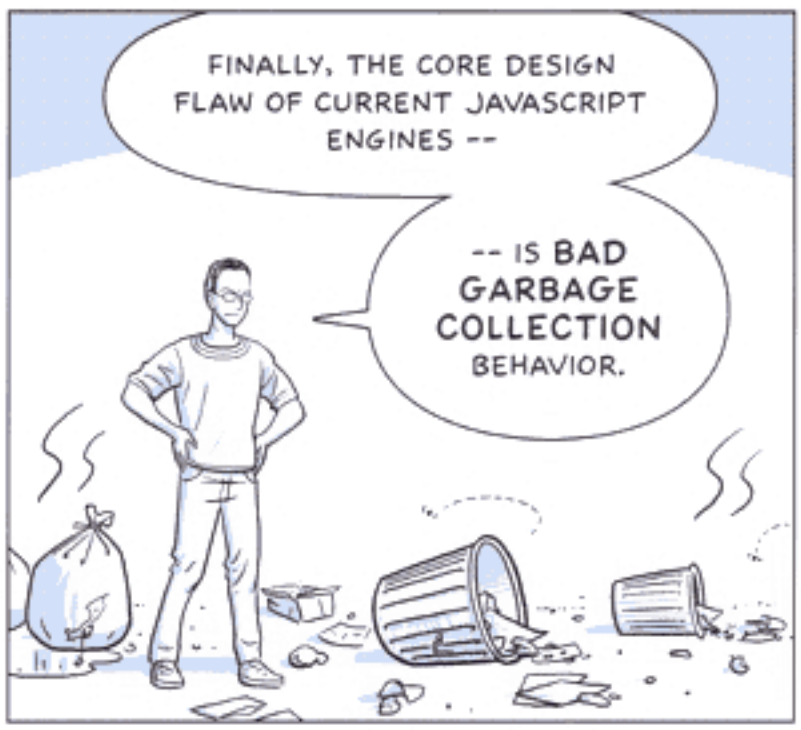


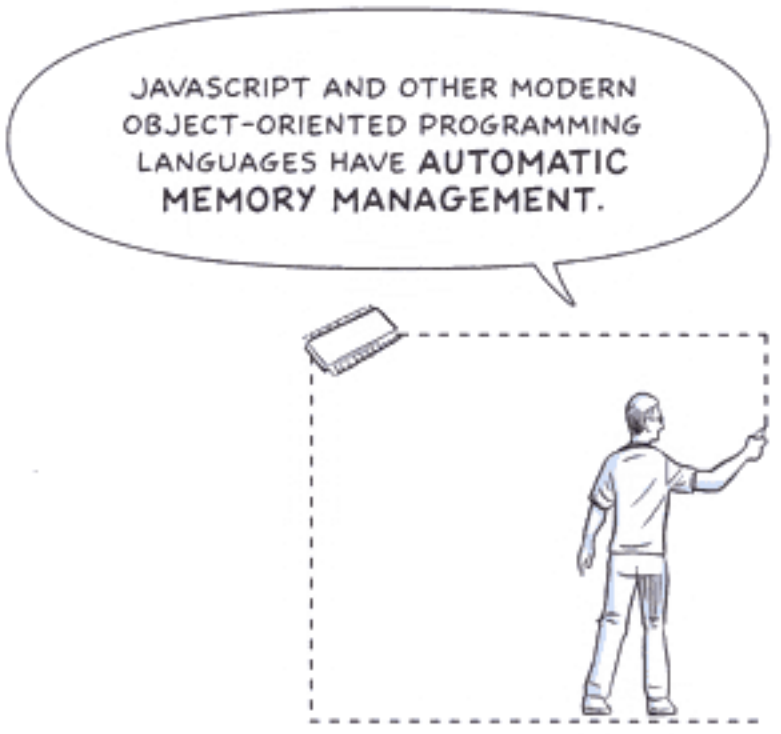




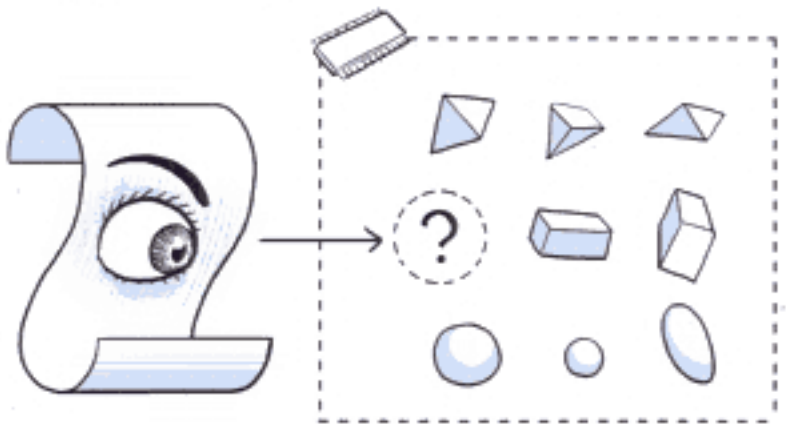
*WHEN YOU INTERPRET ONCE AND COMPILE MACHINE CODE, THEN THAT CODE **IS** YOUR REPRESENTATION OF THE JAVASCRIPT SOURCE CODE AND IT DOESN'T NEED TO BE INTERPRETED, IT JUST **RUNS**.*

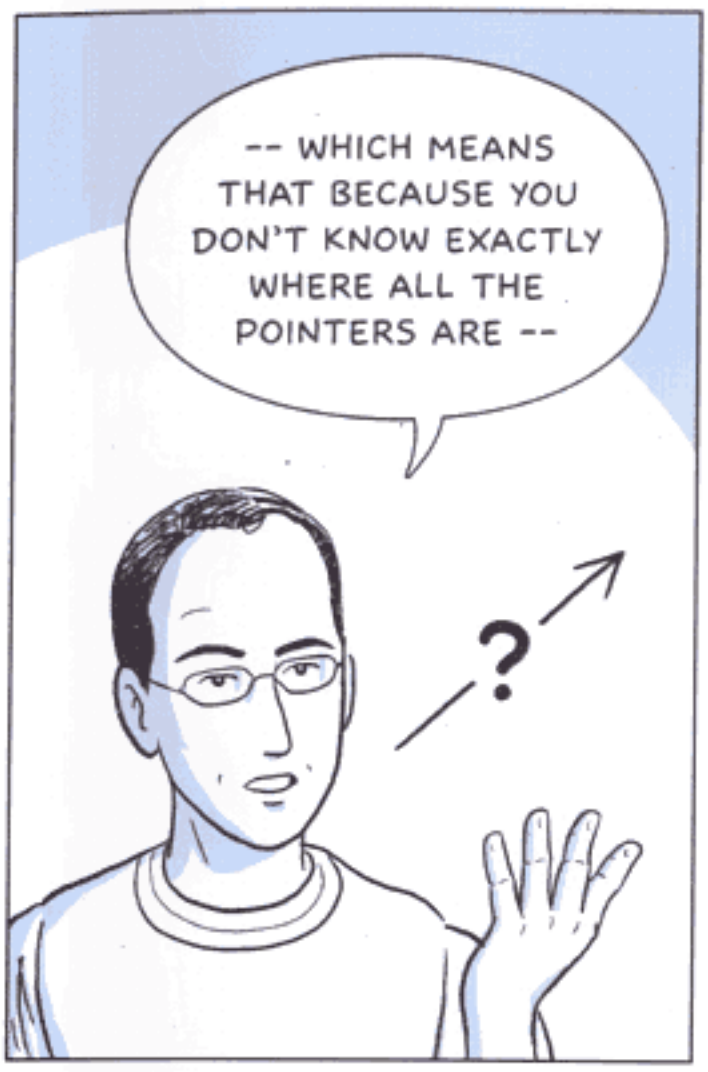
1010100010100010101001010100001010100001010





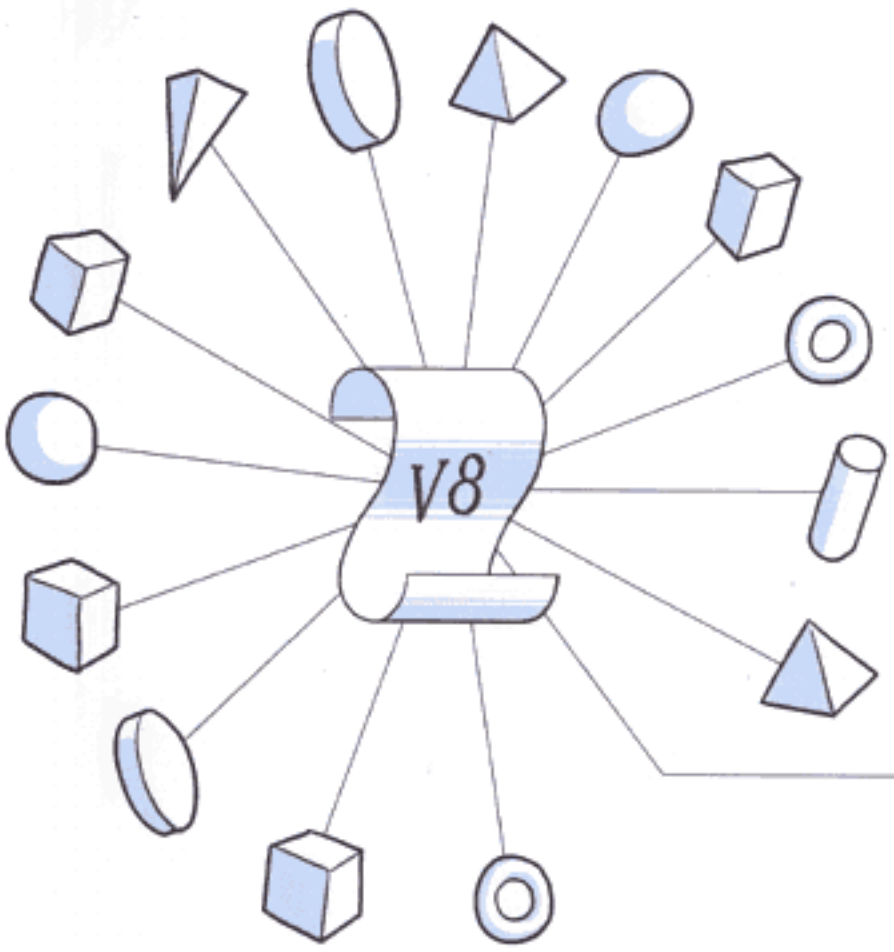
IF YOU DON'T HAVE A REFERENCE TO AN OBJECT ANYMORE, ITS MEMORY CAN BE **RECLAIMED** BY THE SYSTEM. THAT'S GARBAGE COLLECTION, AND ITS A FAIRLY TRIVIAL PROCESS.





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

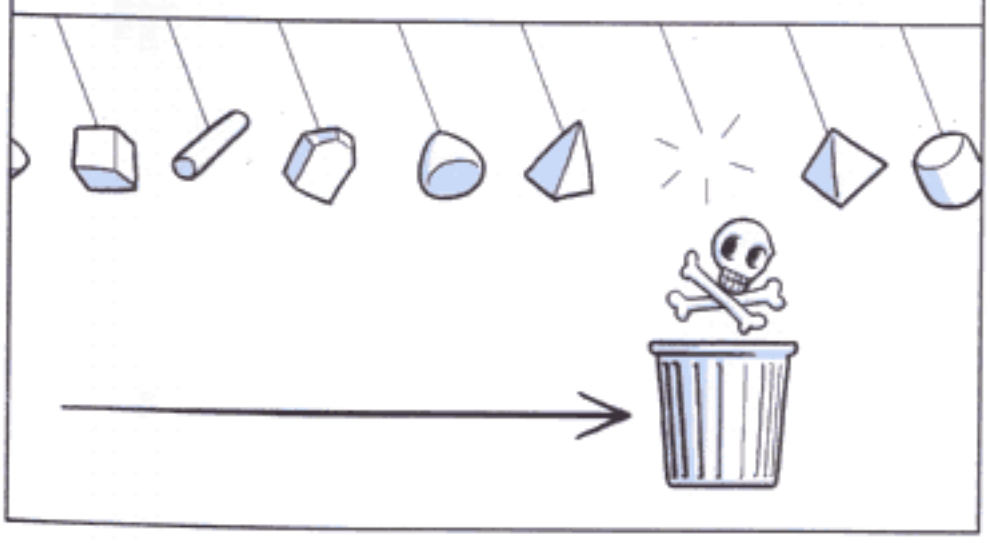
BUT THE ONES THAT SORT OF LOOK LIKE POINTERS COULD ALSO BE INTEGERS THAT JUST HAPPEN TO HAVE THE SAME ADDRESS AS AN OBJECT IN THE OBJECT HEAP.



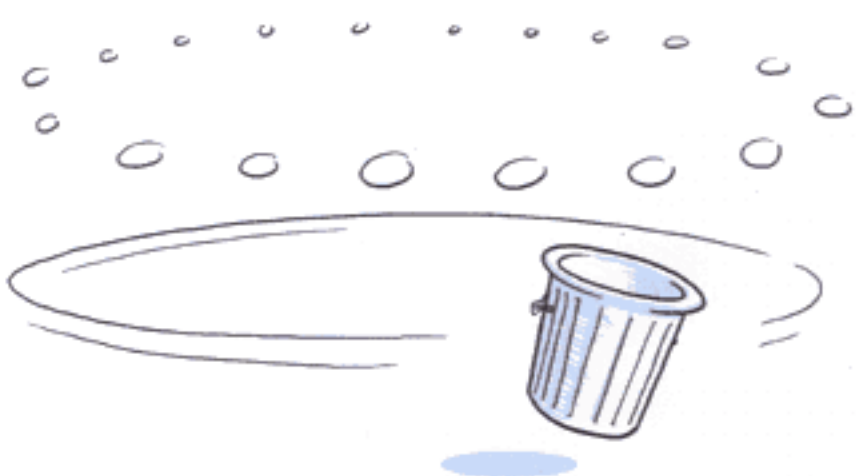
IN V8, WE ARE USING **PRECISE** GARBAGE COLLECTION, SO WE KNOW PRECISELY WHERE **ALL** OF THE POINTERS ARE ON THE STACK AND THIS GIVES US SEVERAL ADVANTAGES.

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.



THIS MEANS MUCH BETTER INTERACTIVE PERFORMANCE OF WEB APPLICATIONS, LIKE SMOOTHER DRAG AND DROPS.

V8 HAS A SPECIFIC API THAT GOOGLE CHROME USES, BUT THE CORE PART OF THE ENGINE IS INDEPENDENT OF THE BROWSER.

V8

GOOGLE CHROME

SO, OTHER BROWSERS CAN INCLUDE IT --

-- OR, IF THERE'S ANOTHER PROJECT THAT JAVASCRIPT CAN APPLY TO, DEVELOPERS CAN TAKE V8 BY ITSELF.

V8

WE HOPE V8'S PERFORMANCE WILL SET A NEW BAR, AND THAT THE OTHER DEVELOPMENT TEAMS WILL CONTINUE TO IMPROVE IN THIS SPACE.

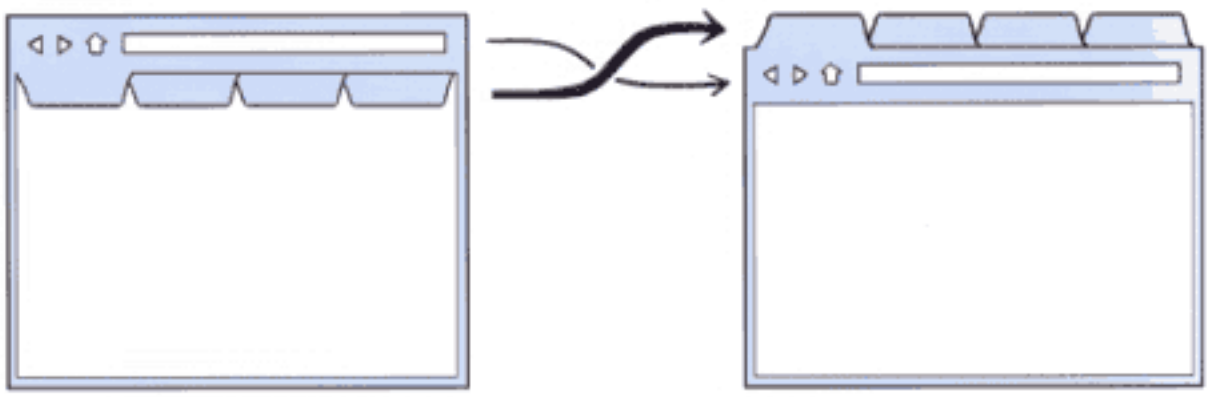
V8

BECAUSE IF YOU LOOK AT ANY OTHER SYSTEM THAT'S BECOME FASTER OVER TIME, WHAT HAPPENS IS THAT YOU GET BIGGER, BETTER, MORE INVENTIVE APPS.

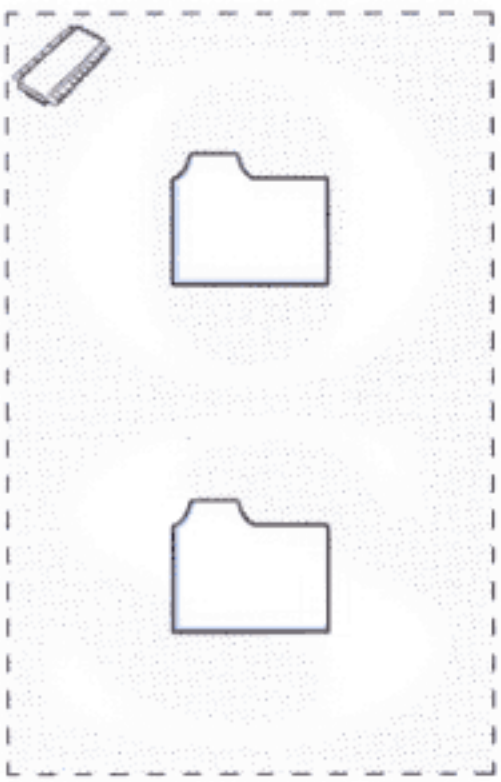
SPEED LIMIT 10^{100}

Part Three

Search and the User Experience

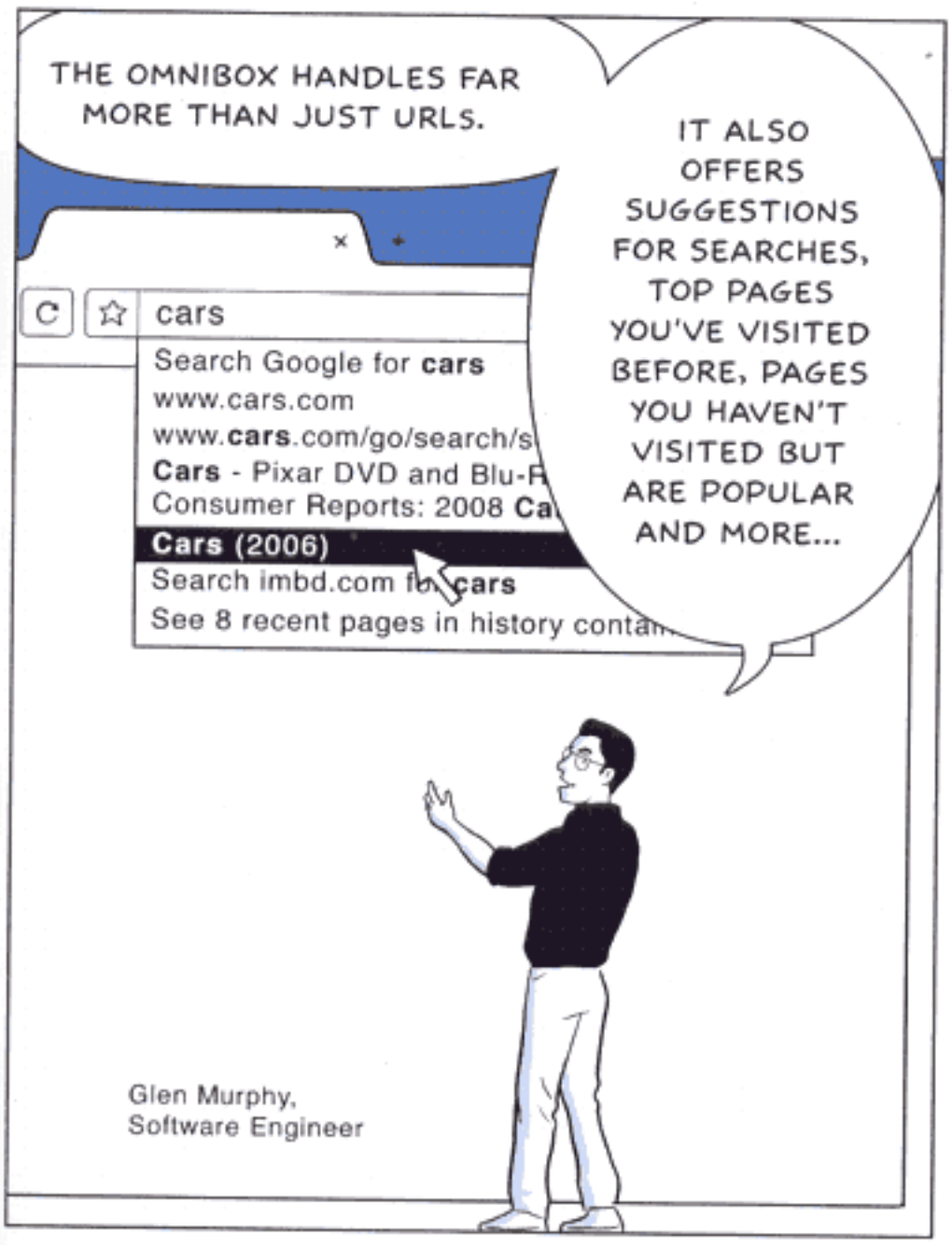


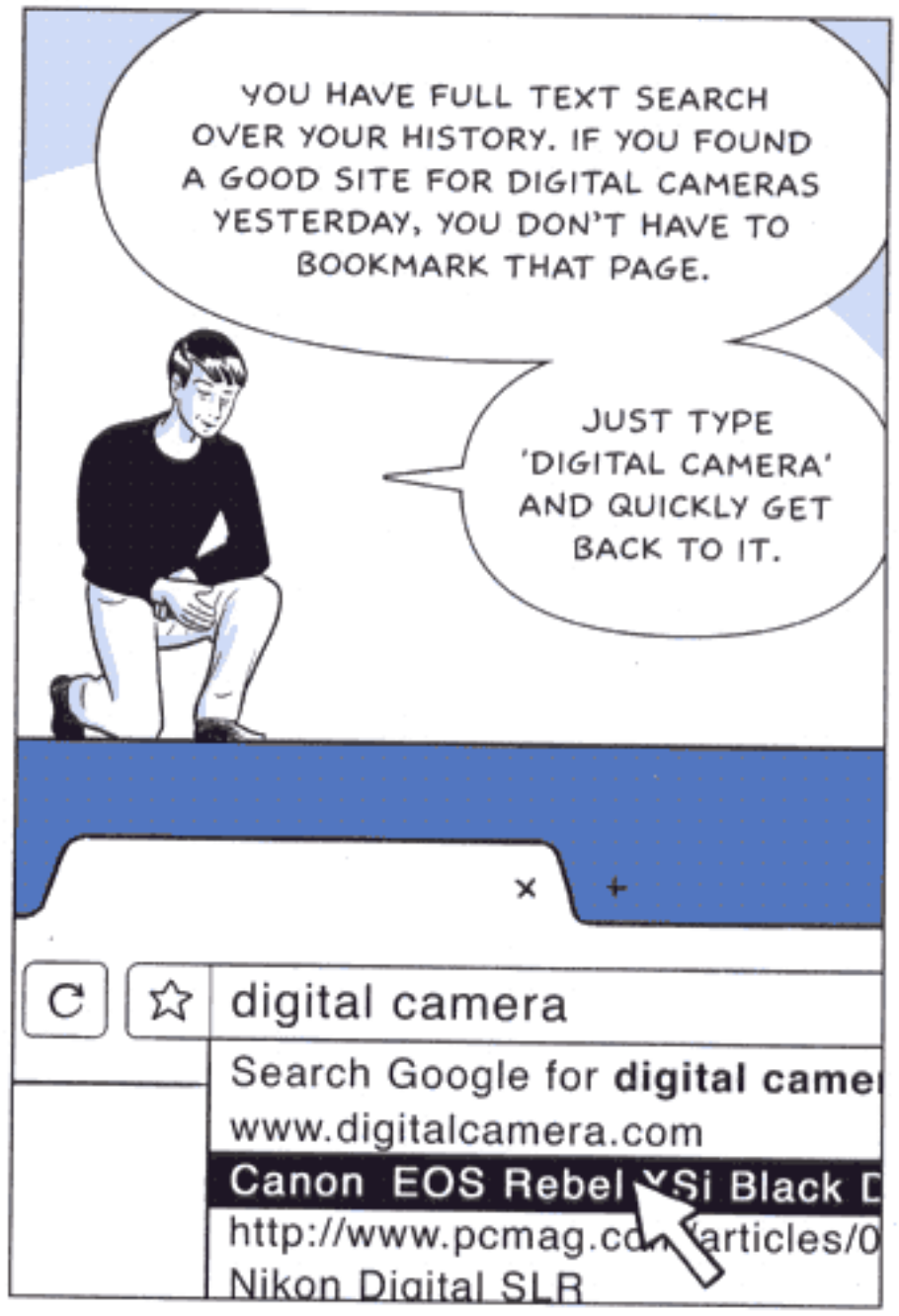
WE COULD DETACH THE TABS EASILY BECAUSE OF THE SEPARATION OF THE BROWSER AND TAB PROCESSES.



AND BECAUSE THE TABS ARE THE MOST IMPORTANT PART OF THE UI, EACH TAB HAS ITS OWN CONTROLS.

AND ITS OWN **URL BOX.**





WHEN THE TEAM SUGGESTED AUTOCOMPLETION IN LINE, I SAID I **HATED** IT WHEN BROWSERS STICK ALL THIS CRAP INTO A LOCATION BAR AS I'M TYPING. IT'S NEVER WHAT I WANT.

BUT, THEY SAID, NO, NO, IT'LL BE FINE, TRUST US -- AND THEY WENT ON AND MADE IT SOMETHING REALLY COMPELLING...

INLINE COMPLETIONS WILL NEVER FLICKER, NEVER FLASH. IT'S PERFECTLY, AESTHETICALLY NON-DISTRACTING.

cars
Search Google for car
www.cars.com
www.cars.com/go/se
Cars - Pixar DVD and
Consumer Reports. 20
Cars (2006)
Search imbd.com fo
See 8 recen

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

TYPE c return AND YOU MIGHT GO STRAIGHT TO cnn.com --

TAP! TAP!

-- BUT **NEVER** TO cnn.com/2008/politics/07/27/campaign.wrap/index.html?iref=mpstor

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

Search Books Tufte

-- THE SEARCH BOXES ON THOSE PAGES ARE CAPTURED ON YOUR LOCAL SYSTEM --

-- SO YOU CAN SEARCH THOSE SAME SITES WITH DIFFERENT TERMS LATER ON, STRAIGHT FROM THE ADDRESS BAR, BY STARTING THE SITE'S NAME AND PRESSING 'TAB'.

a tab

Search Amazon: Zamfir

CLICK! return

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.

Most visited

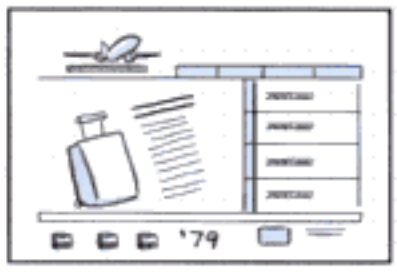
Evan Martin, Software Engineer

Gmail

October

New York Times

Southwest



Slashdot

Wells Fargo

LOLCats

Glen Murphy, Software Engineer

Searches

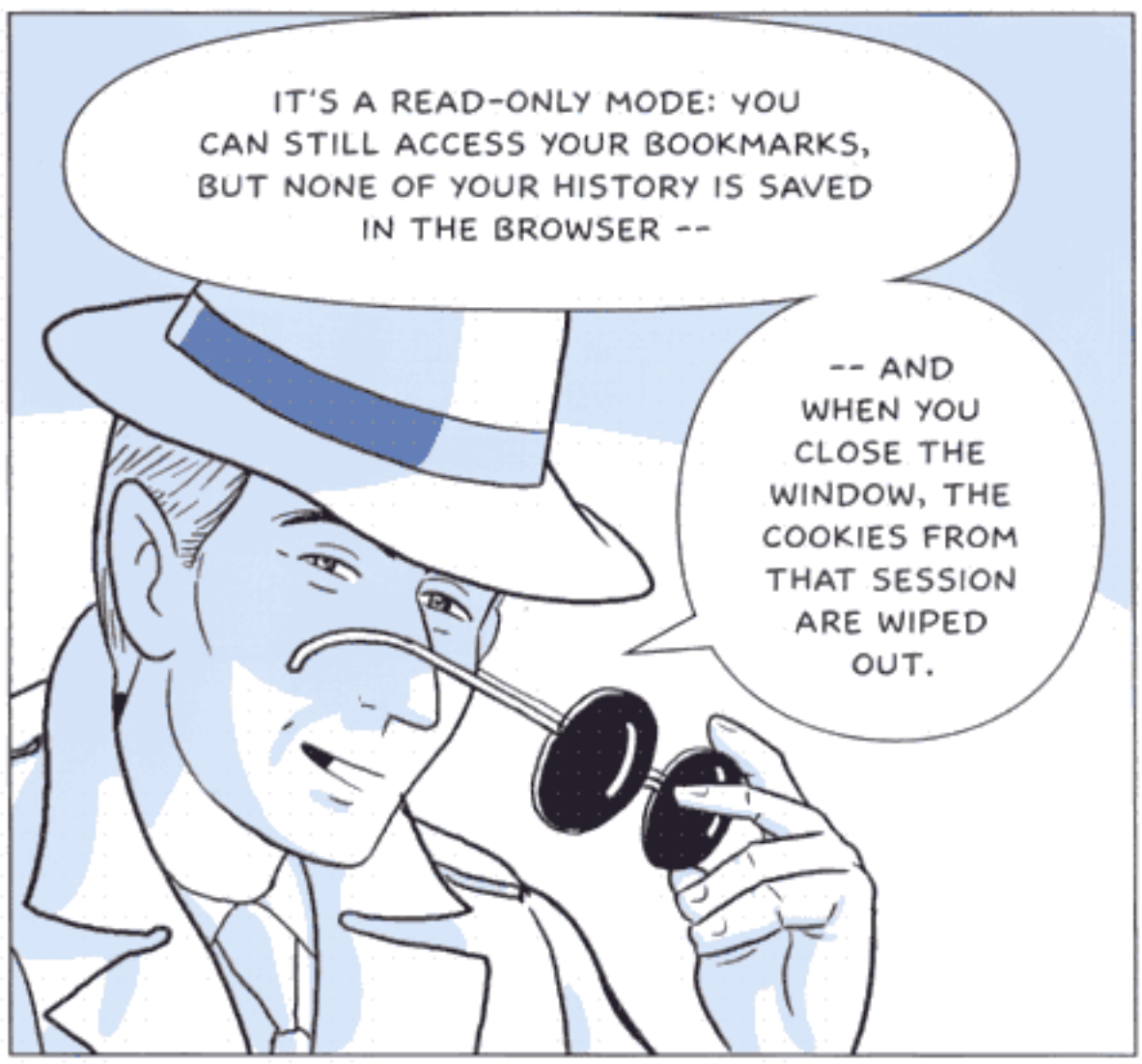
- History
- Amazon
- Mirriam-Webster
- imdb

Recently bookmarked

Recently closed tabs

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.



WANT TO KEEP A SURPRISE GIFT A SECRET?

Engagements
Weddings
Anniversaries
Gifts
Find

JUST CONTINUE TO BROWSE NORMALLY IN ANY OTHER WINDOW.

THERE'S NO CONCEPT OF A DRIVE-BY POP-UP IN CHROME. JAVASCRIPT HAS NO WAY TO FORCE A POP-UP INTO YOUR WORLD.

POP-UPS ARE SCOPED TO THE TAB THEY CAME FROM --

BU

EASY MONEY!

LOW! LOW RATES!

HOT! HOT! GIRLS!

BIG! BIG! BUCKS!

WINNER!

-- AND CONFINED THERE.

GULP!

IF IT'S SOMETHING YOU **WANT**, THOUGH --

Audio Player

-- JUST DRAG IT OUT AND IT'LL BE PROMOTED TO ITS OWN WINDOW.

BURP!

DEVELOPERS CALL THE UI FRAME OF THE BROWSER ITS "CHROME."

WE WANTED TO REDUCE THE "CHROME" OF GOOGLE CHROME. IN THE CASE OF WEBAPPS, WE'VE MADE IT SO YOU CAN LAUNCH THEM IN THEIR OWN STREAMLINED WINDOW, WITHOUT THE URL BOX AND BROWSER TOOLBAR.

Start Pag ail ndar Documents Sites

madeupa ress mail.com

Gmail™ by Google BETA

Compose Mail

Inbox (994)

Starred

Chats

Archive Report S

Select: All, None, Re

Google Alerts

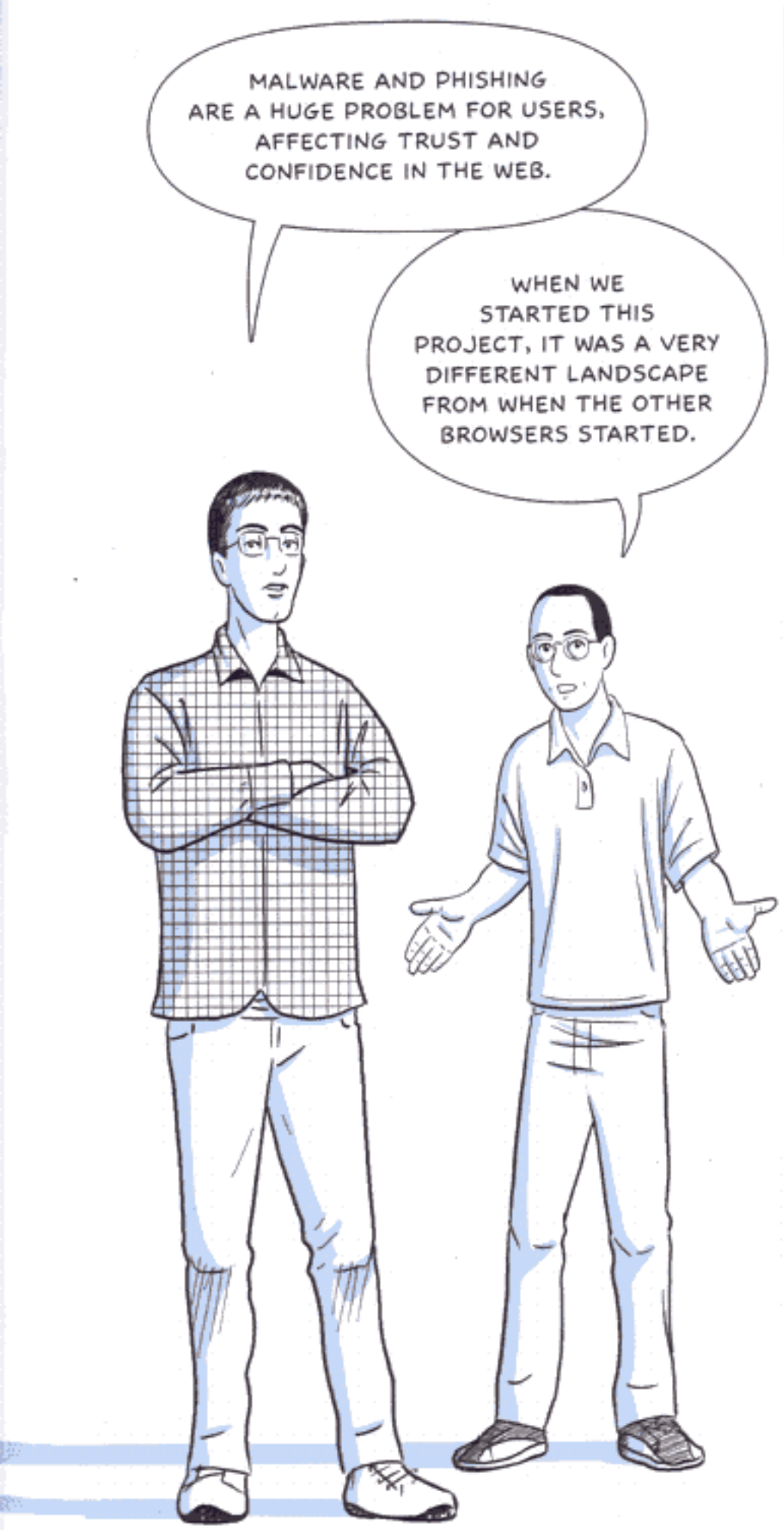
Harold Kumar

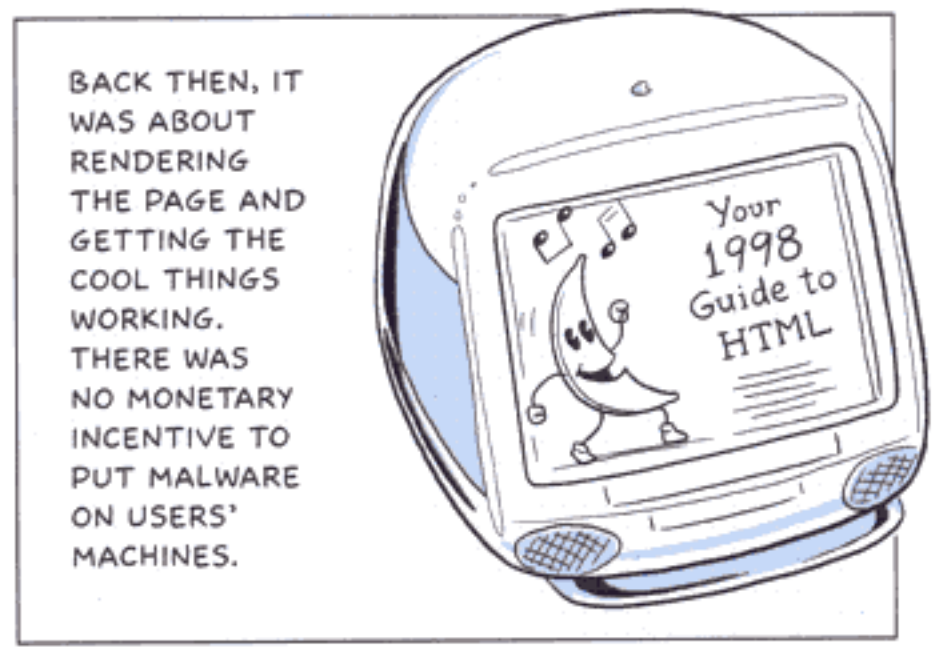
WE DON'T WANT TO INTERRUPT ANYTHING THE USER IS TRYING TO DO.

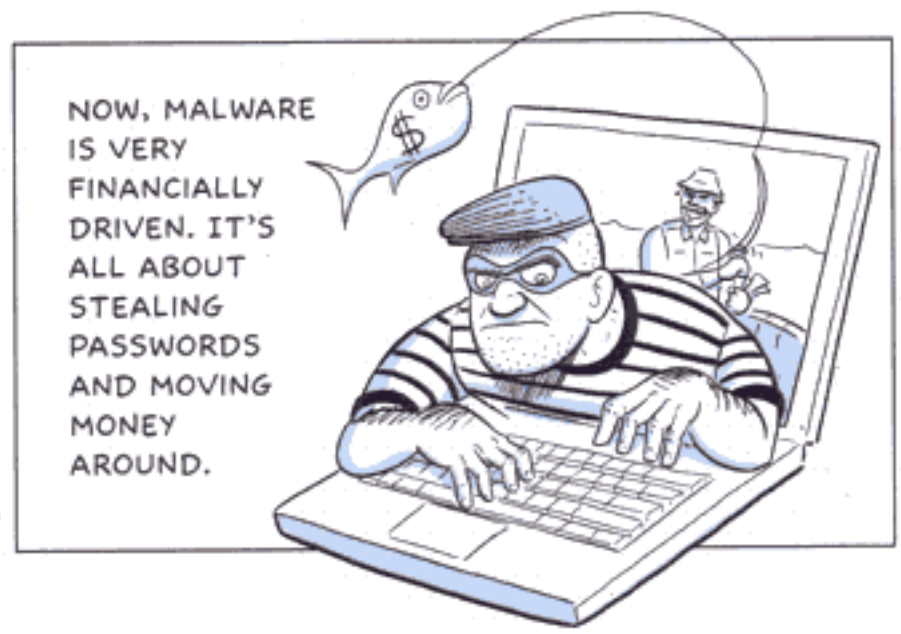
IF YOU CAN JUST **IGNORE** THE BROWSER, WE'VE DONE A GOOD JOB.

Part Four

Security, Sandboxing and Safe Browsing



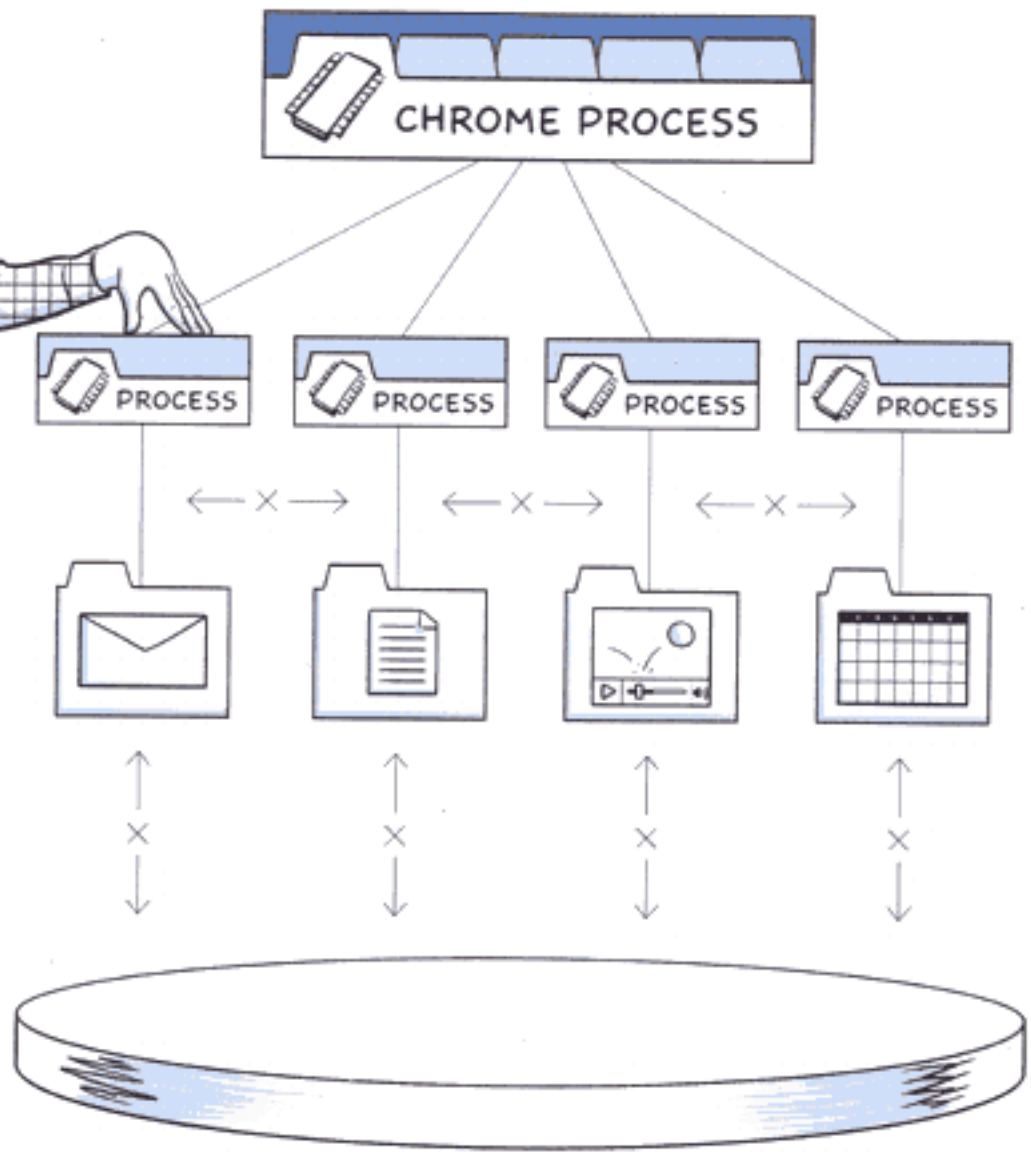




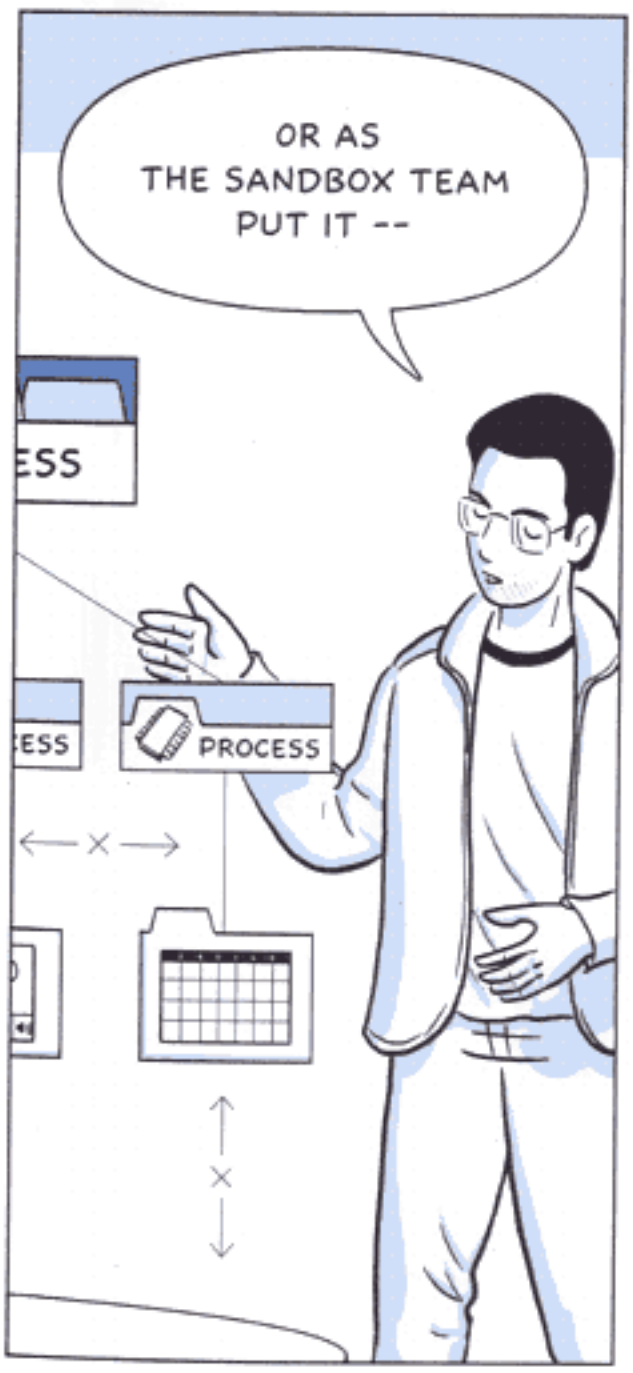
WITH **SANDBOXING**, OUR GOAL IS TO PREVENT MALWARE FROM INSTALLING ITSELF ON YOUR COMPUTER OR USING WHAT HAPPENS IN ONE TAB TO AFFECT WHAT HAPPENS IN ANOTHER.

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

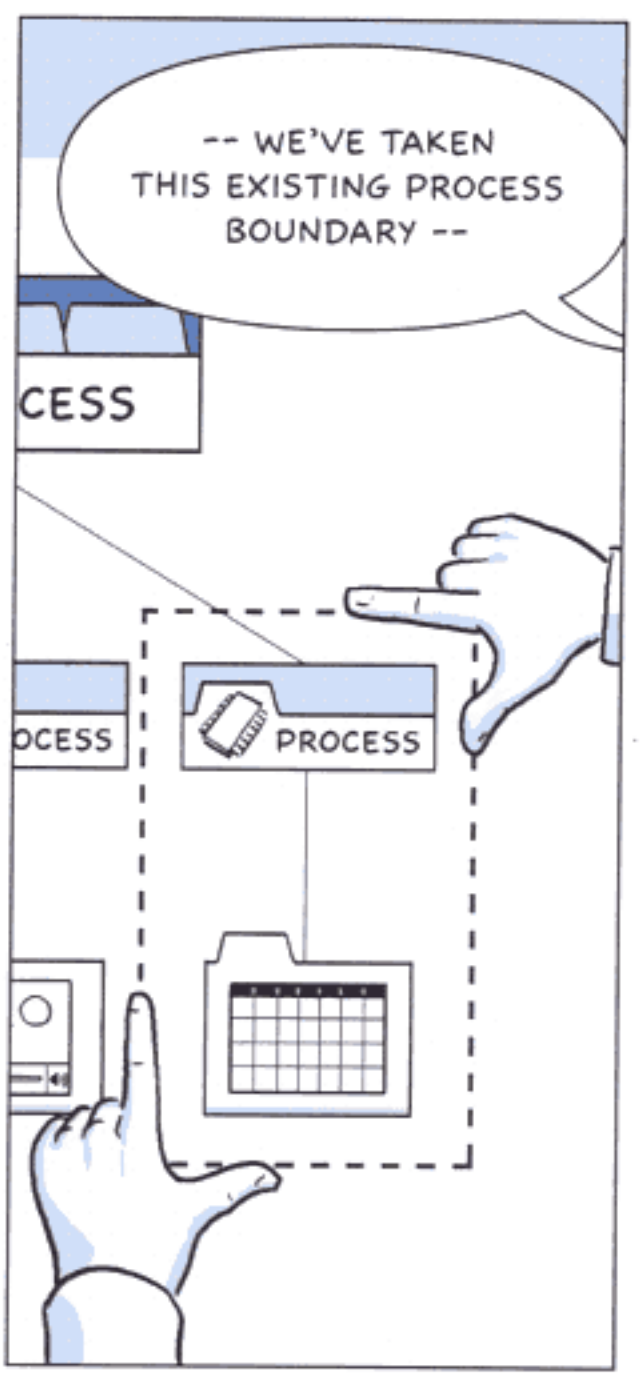
THEY CAN COMPUTE BUT THEY CAN'T WRITE FILES TO YOUR HARD DRIVE OR READ FILES FROM SENSITIVE AREAS LIKE YOUR DOCUMENTS OR DESKTOP.



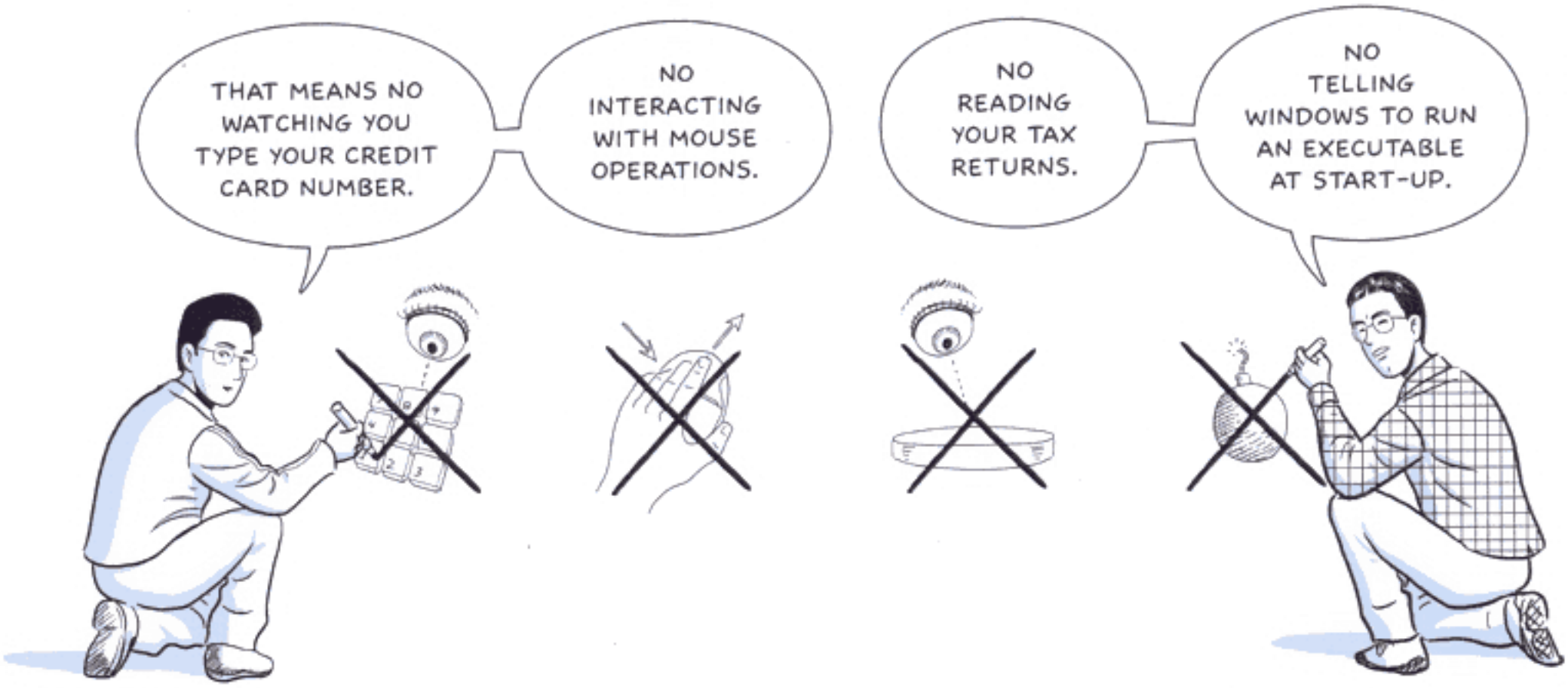
OR AS THE SANDBOX TEAM PUT IT --



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



-- AND MADE IT INTO A **JAIL**.

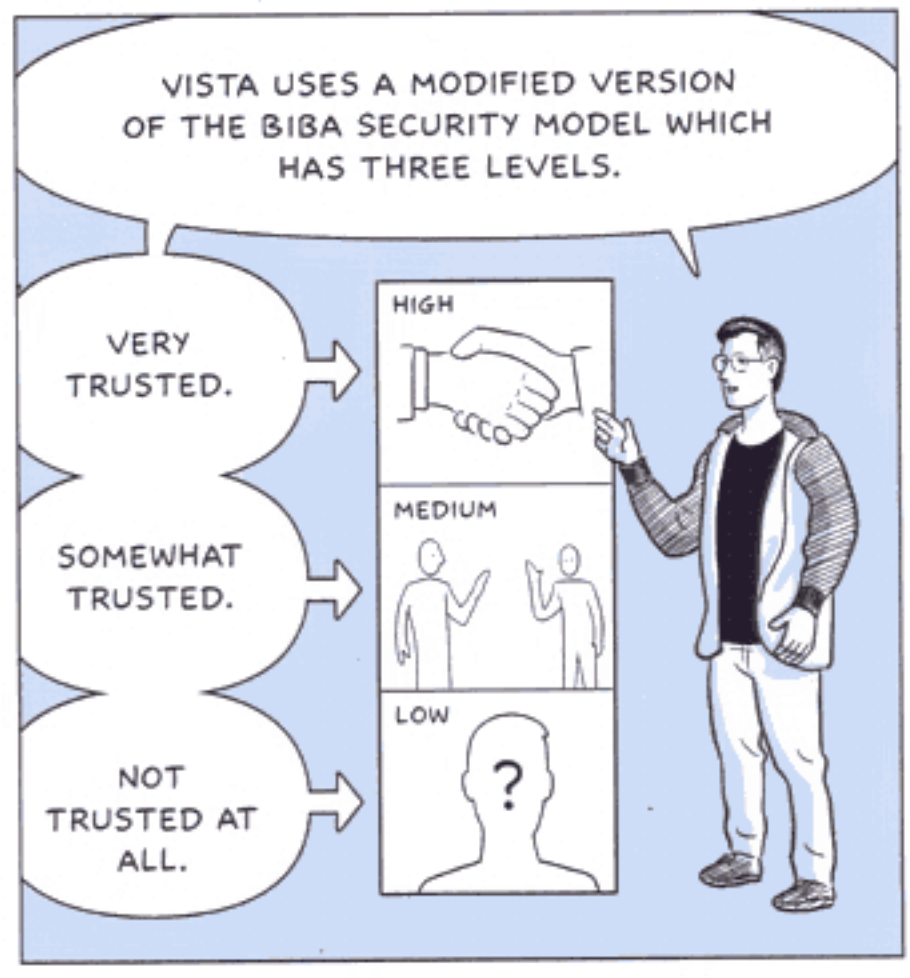

THAT MEANS NO WATCHING YOU TYPE YOUR CREDIT CARD NUMBER.
NO INTERACTING WITH MOUSE OPERATIONS.
NO READING YOUR TAX RETURNS.
NO TELLING WINDOWS TO RUN AN EXECUTABLE AT START-UP.


SOMETHING BAD COULD BE RUNNING IN THIS TAB --
PROCESS


-- BUT AS SOON AS YOU CLOSE IT, IT'S GONE.
POP!
POP!


NO EFFECT ON YOUR MACHINE AND NO EFFECT ON OTHER PROCESSES.


THE PERIMETER OF THE SANDBOX IS LARGELY BASED ON PERMISSIONS.
?
Mark Larson, Program Manager


VISTA USES A MODIFIED VERSION OF THE BIBA SECURITY MODEL WHICH HAS THREE LEVELS.
VERY TRUSTED.
SOMEWHAT TRUSTED.
NOT TRUSTED AT ALL.
HIGH
MEDIUM
LOW
?

THIS LEVEL IS FOR BACKUP SYSTEMS, PROGRAMS THAT UPDATE, ETC.

HIGH

MEDIUM

LOW

?

THIS LEVEL IS FOR EVERYTHING THE USER RUNS NORMALLY. NOTEPAD, SOLITAIRE, CALCULATOR...

HIGH

MEDIUM

LOW

?

READING IS ALLOWED FROM **LOW** TO **HIGH** --

HIGH

MEDIUM

LOW

?

HIGH

MEDIUM

LOW

?

-- BUT **WRITING** IS ALLOWED ONLY FROM **HIGH** TO **LOW.**

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

HIGH

MEDIUM

LOW

?

THE PROBLEM IS THAT UNLIKE THE HIGH LEVEL, THERE IS A LOT OF SENSITIVE INFO HERE --

HIGH

MEDIUM

LOW

?

-- THAT **THIS** LEVEL SHOULD **NOT** BE ALLOWED TO READ!

HIGH

MEDIUM

LOW

?

IN OUR MODEL, THERE'S THE **USER**, AND THERE'S THE **SANDBOX**. AND ANY COMMUNICATIONS **MUST** BE INITIATED BY THE USER.

HIGH

NONE

THIS SIDE CAN **REPLY** BUT IT HAS NO WAY TO ACCESS ANYTHING THAT ISN'T EXPLICITLY PROVIDED BY THE USER.

HIGH

NONE

WE CAN DO THIS BECAUSE ALL OUR CODE IS NEW. WE'RE WRITING THE CODE, SO GOOGLE CHROME HAS FULL CONTROL OVER THIS.

HIGH

NONE

SMASH!

HIGH

NONE

WITH ONE EXCEPTION -- **PLUGINS**.

HIGH

NONE

BECAUSE WEBPAGES ARE **MORE** THAN JUST **HTML** AND **JAVASCRIPT**.

IN TERMS OF PERMISSIONS ON THE SYSTEM, GOOGLE CHROME'S RENDERER MAY RUN AT VERY LOW PRIVILEGES, BUT THERE ARE **PLUGINS** THAT RUN AT THE SAME LEVEL OR EVEN HIGHER THAN THE BROWSER.

USER

SAND-BOX

PROCESS

CHROME PROCESS

PROCESS

PROCESS

PROCESS

PROCESS

HIGH READ-WRITE ACCESS

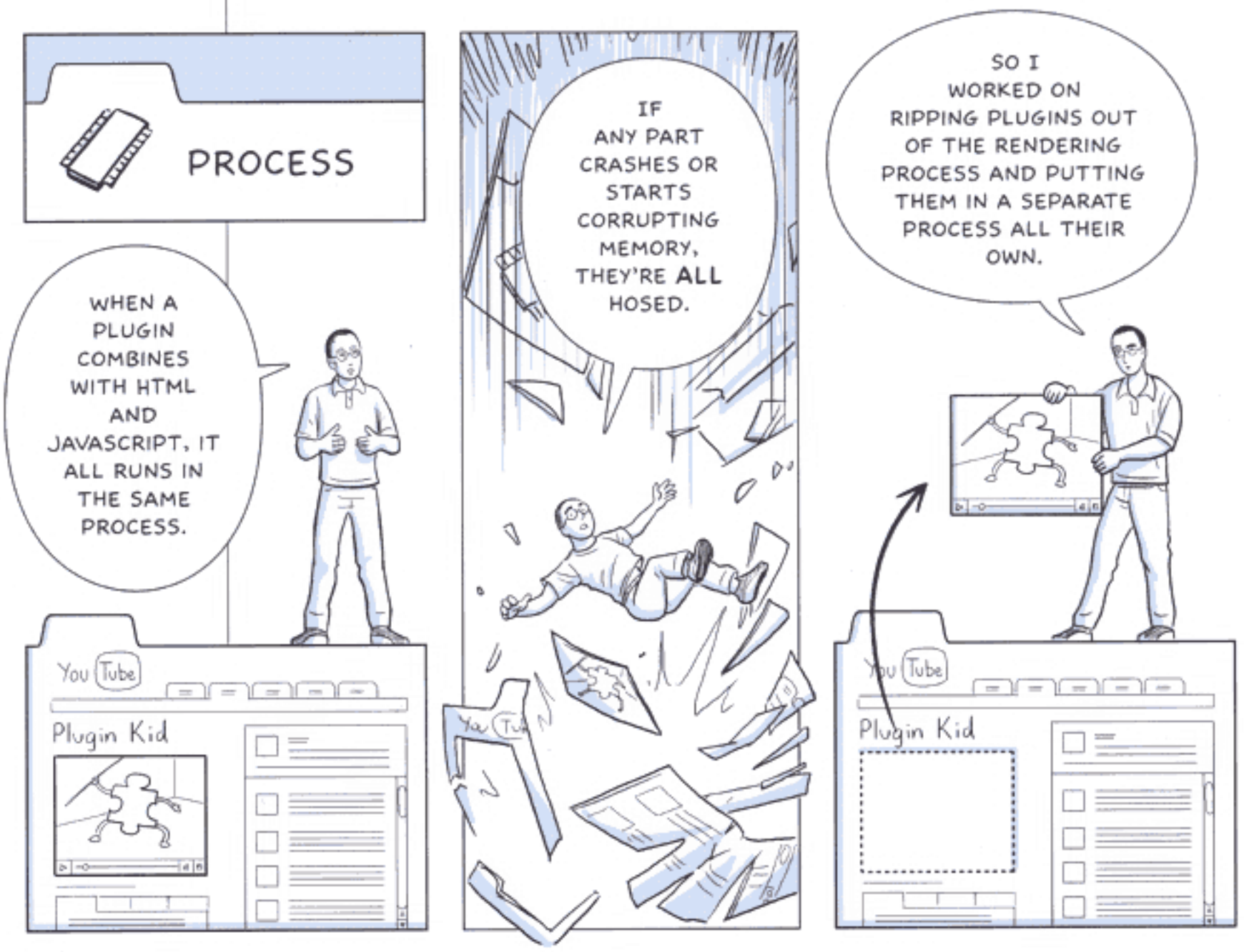
MEDIUM READ-WRITE ACCESS

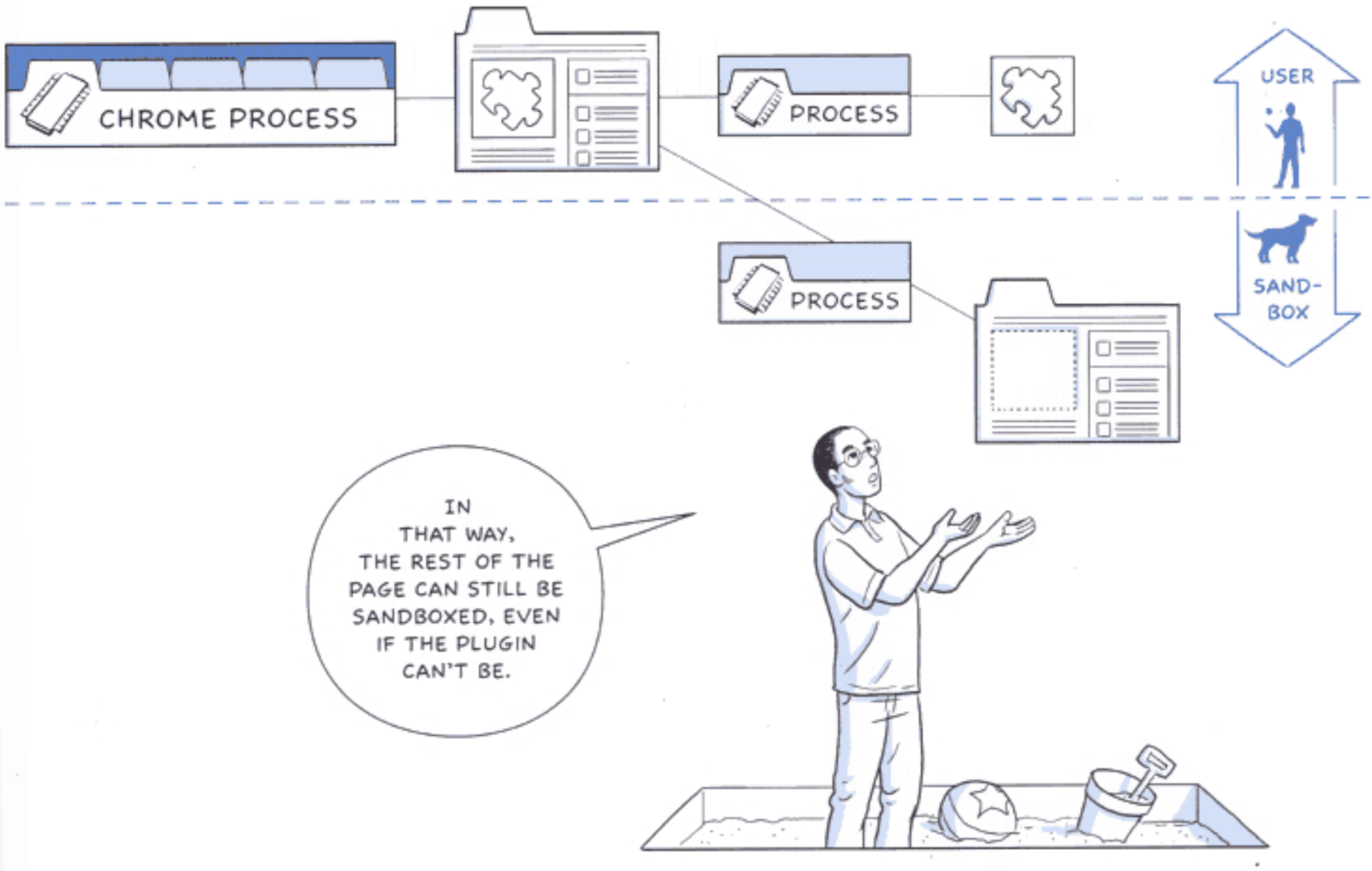
PLUGINS HAVE CAPABILITIES THAT AREN'T PUBLIC STANDARDS, SO WE CAN'T SANDBOX THESE YET.

THOUGH WITH SOME SMALL CHANGES ON THE PART OF THE PLUGIN MAKERS, WE CAN GET THEM TO RUN AT A LOWER PRIVILEGE WHICH WOULD BE MUCH MUCH SAFER.

AND MEANWHILE, WE HAVE A HUGE SURFACE AREA REDUCTION IN VULNERABILITY, FROM ALL **THIS** --

-- TO **THIS.**


PROCESS
WHEN A PLUGIN COMBINES WITH HTML AND JAVASCRIPT, IT ALL RUNS IN THE SAME PROCESS.
YouTube
Plugin Kid
IF ANY PART CRASHES OR STARTS CORRUPTING MEMORY, THEY'RE ALL HOSED.
SO I WORKED ON RIPPING PLUGINS OUT OF THE RENDERING PROCESS AND PUTTING THEM IN A SEPARATE PROCESS ALL THEIR OWN.
YouTube
Plugin Kid


CHROME PROCESS
PROCESS
PROCESS
USER
SAND-BOX
IN THAT WAY, THE REST OF THE PAGE CAN STILL BE SANDBOXED, EVEN IF THE PLUGIN CAN'T BE.

SANDBOXING CAN HELP PROTECT USERS FROM MALWARE, BUT THEY CAN STILL BE TRICKED BY **PHISHING**.

IN A TYPICAL PHISHING SCHEME, AN ATTACKER SENDS OUT MAIL SAYING, "I'M YOUR BANK, YOUR ACCOUNT IS COMPROMISED, GIVE ME YOUR SSN SO I CAN VERIFY, ETC..."

THEN THEY SEND USERS TO A NEARLY EXACT COPY OF THEIR BANK'S WEBSITE AND START STEALING THEIR INFORMATION.

http://www.(bank's name).com

View Your Accounts

Go to: Account Summary

Username:

http://www.(bank's name).login.com

View Your Accounts

Go to: Account Summary

Username:

A LOT OF THESE GET TAKEN DOWN SOMEWHERE AROUND 24 HOURS --

-- THOUGH A FEW LAST UP TO 7 DAYS OR MORE.

THE HARD PART IS FINDING THEM CLOSE TO **TIME ZERO**.

TICK!
TICK!
TICK!
TICK!
TICK!

GOOGLE CHROME IS CONTINUALLY DOWNLOADING LISTS OF HARMFUL SITES, ONE FOR PHISHING, ONE FOR MALWARE.

IF YOU GO TO A WEBSITE THAT MATCHES THE LIST, YOU'LL GET A WARNING.

DANGER! DANGER!

WE'VE MADE THIS SERVICE FREELY AVAILABLE. WE'RE HAPPY TO GIVE IT AWAY. IT'S A PUBLIC API.

THERE'S A SECOND LIST OF MALWARE WEBSITES. WEBSITES WHERE A TON OF BAD THINGS MIGHT HAPPEN TO YOUR COMPUTER, JUST ON ARRIVAL.

WHEN WE DISCOVER MALICIOUS CONTENT, WE NOTIFY THE OWNER OF A WEBSITE, WHO USUALLY WASN'T INTENDING TO BE MALICIOUS, AND THEY CAN TAKE THIS INFORMATION AND CLEAN UP THEIR SITE.

=AHEM=

?

OH, SORRY!

Part Five

Gears, Standards and Open Source

Aaron Boodman,
Software Engineer

ANOTHER THING WE BUILT INTO GOOGLE CHROME IS **GEARS.**

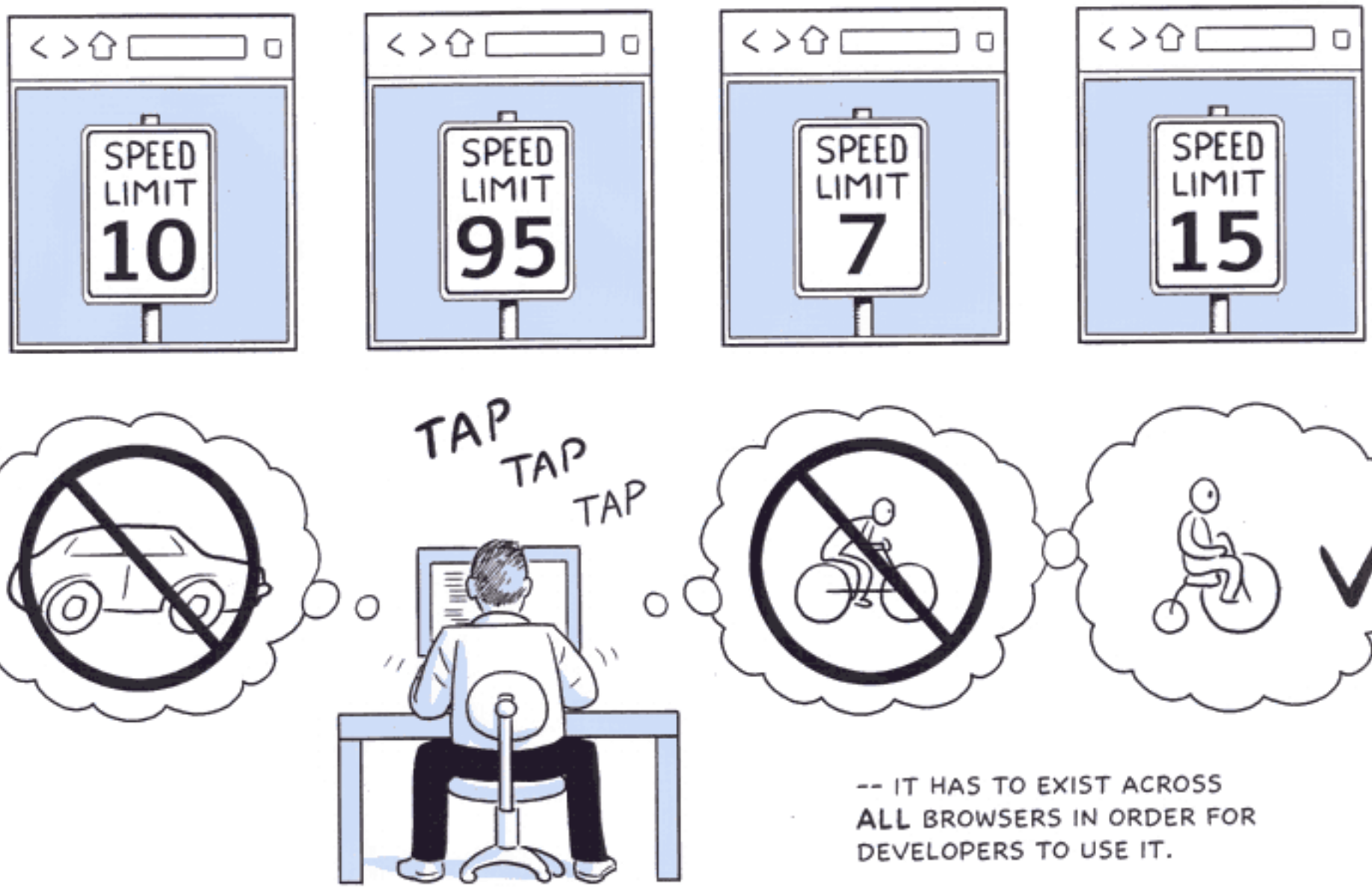
GEARS BASICALLY ADDS AN API TO YOUR BROWSER -- AN EXTENSION THAT IMPROVES ITS CAPABILITIES.

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

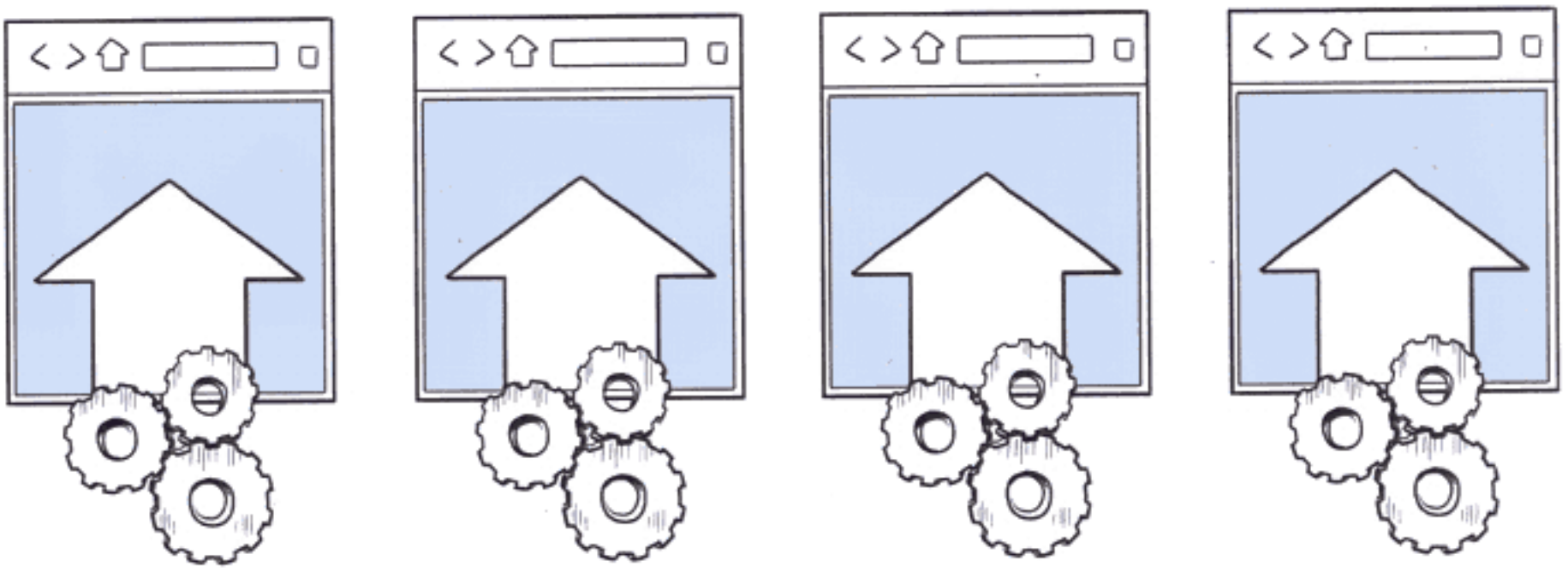
THE BROWSER PROJECT IS AN EFFORT TO MAKE THE WEB BETTER FOR **USERS.**

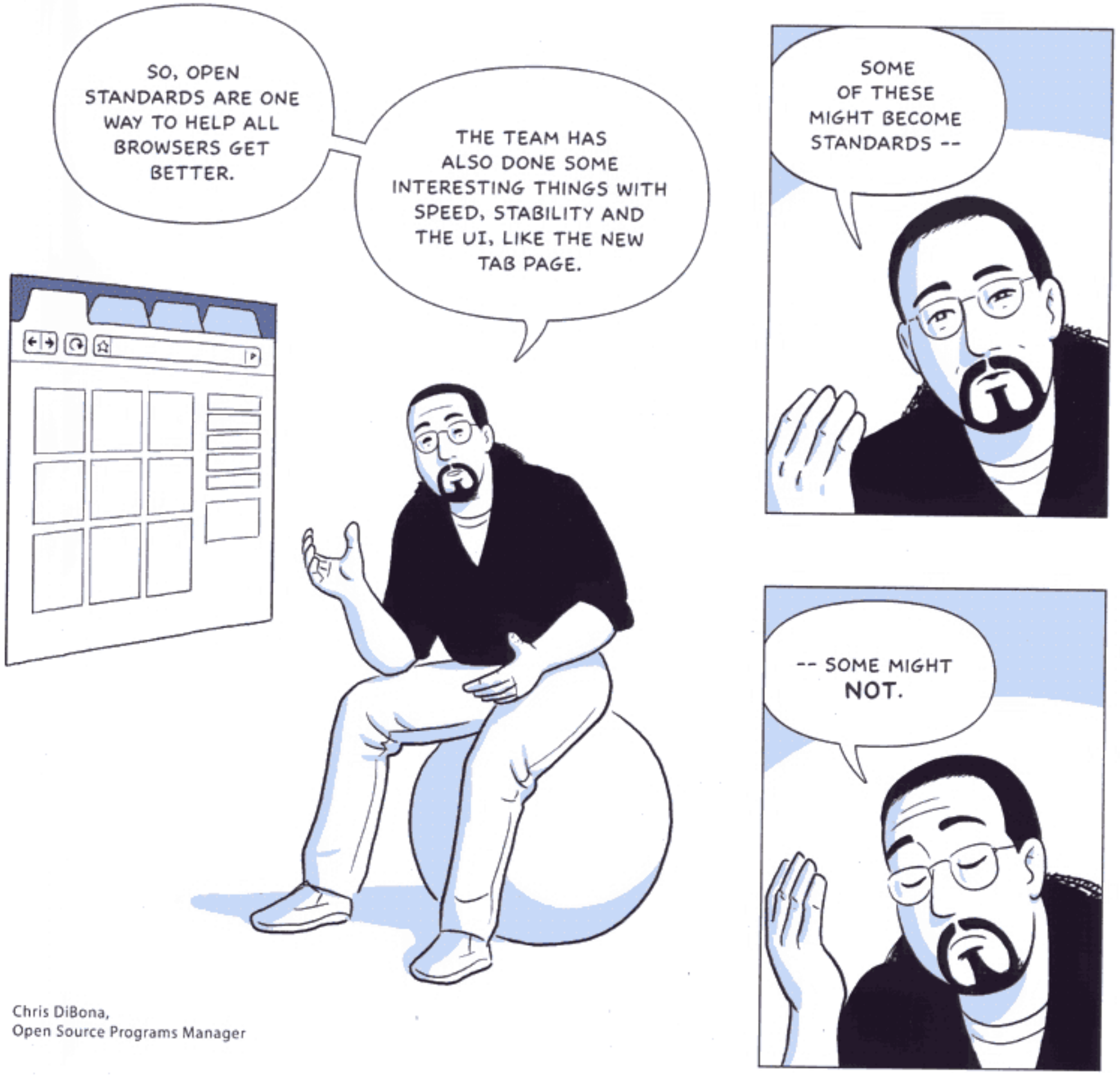
THE GEARS TEAM WANTS TO MAKE THE WEB BETTER FOR **DEVELOPERS.**

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 --

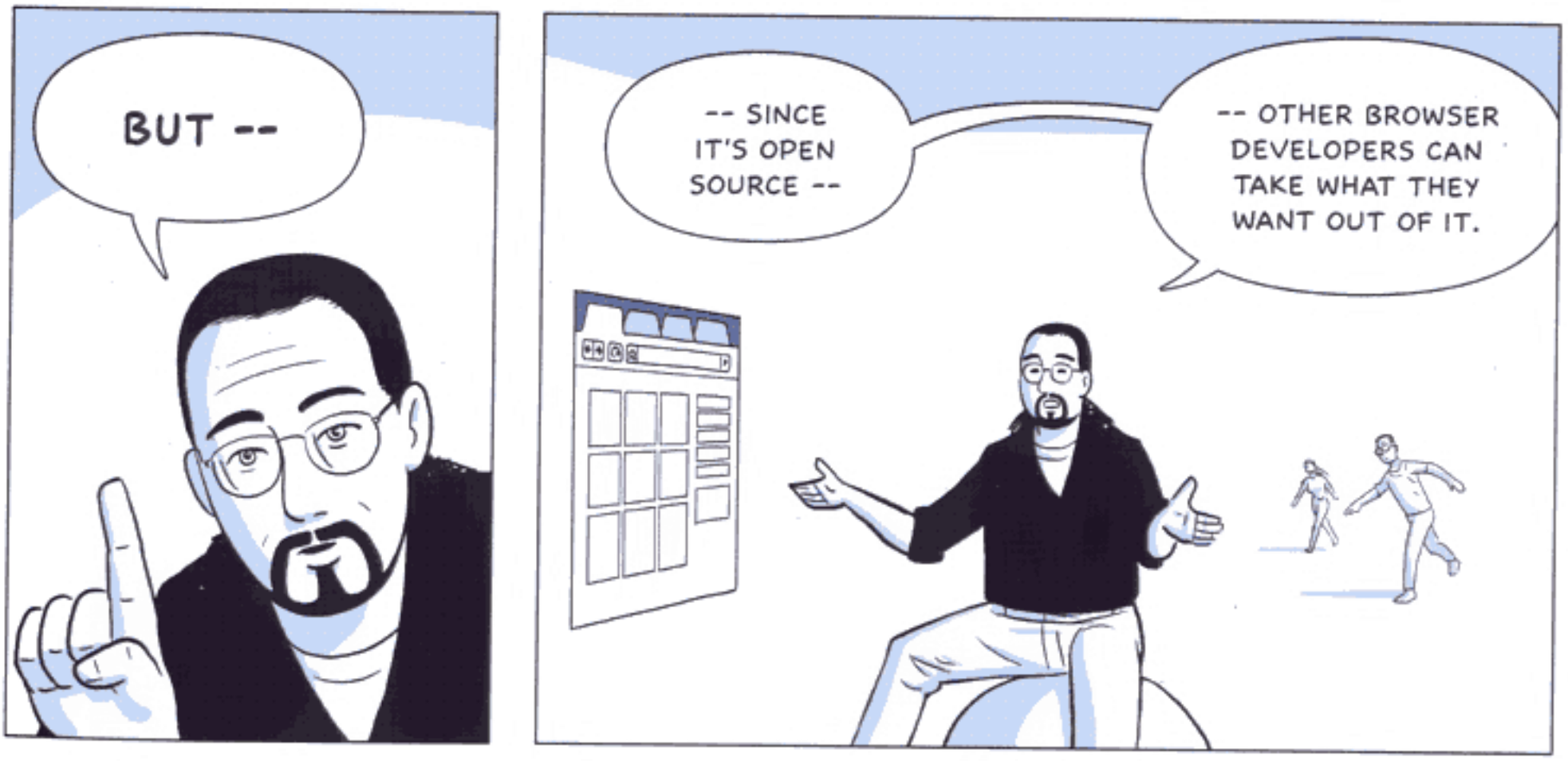


-- IT HAS TO EXIST ACROSS **ALL** BROWSERS IN ORDER FOR DEVELOPERS TO USE IT.

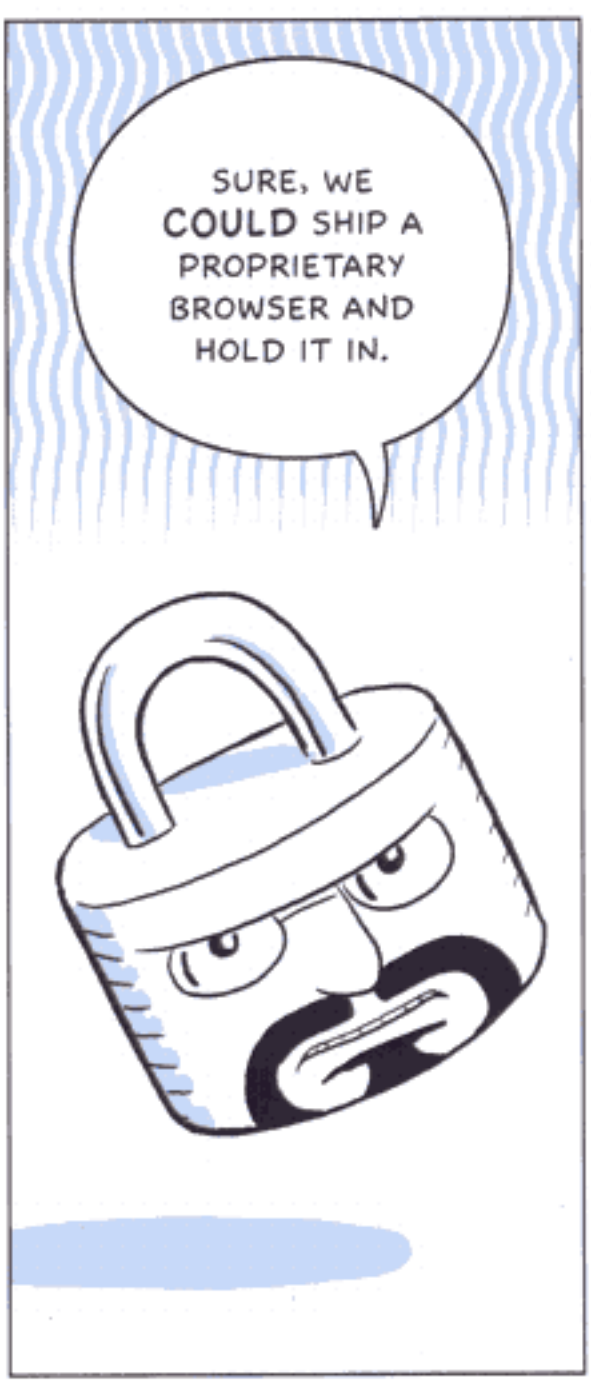


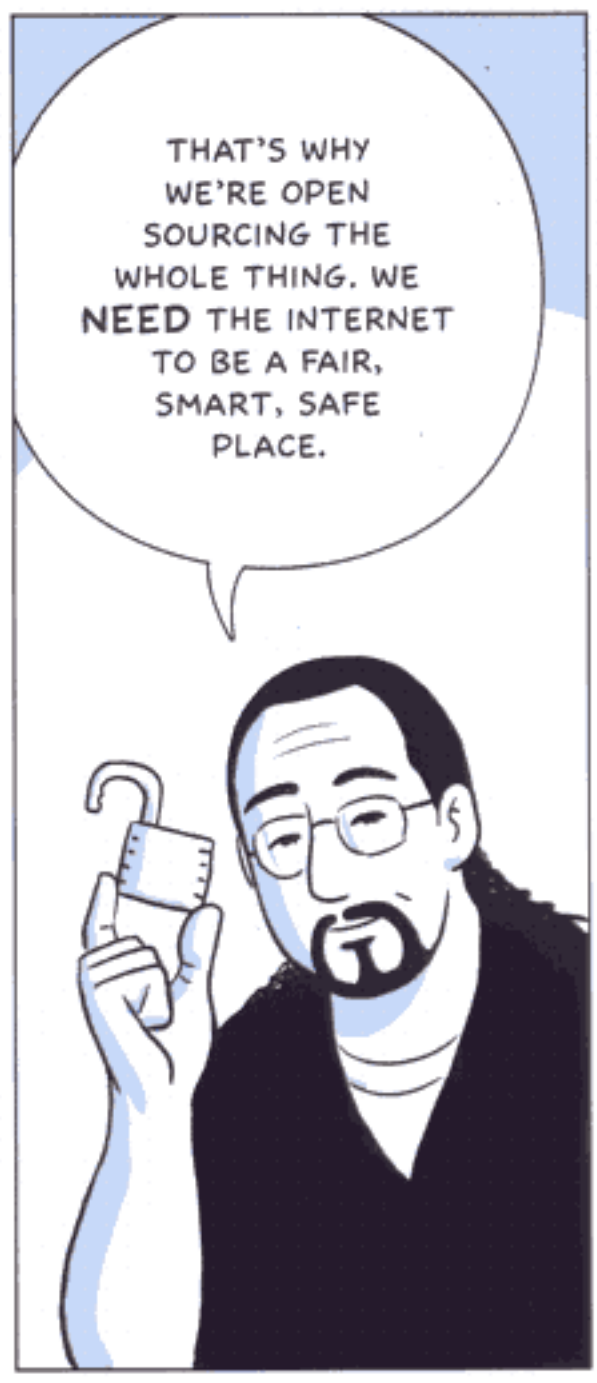


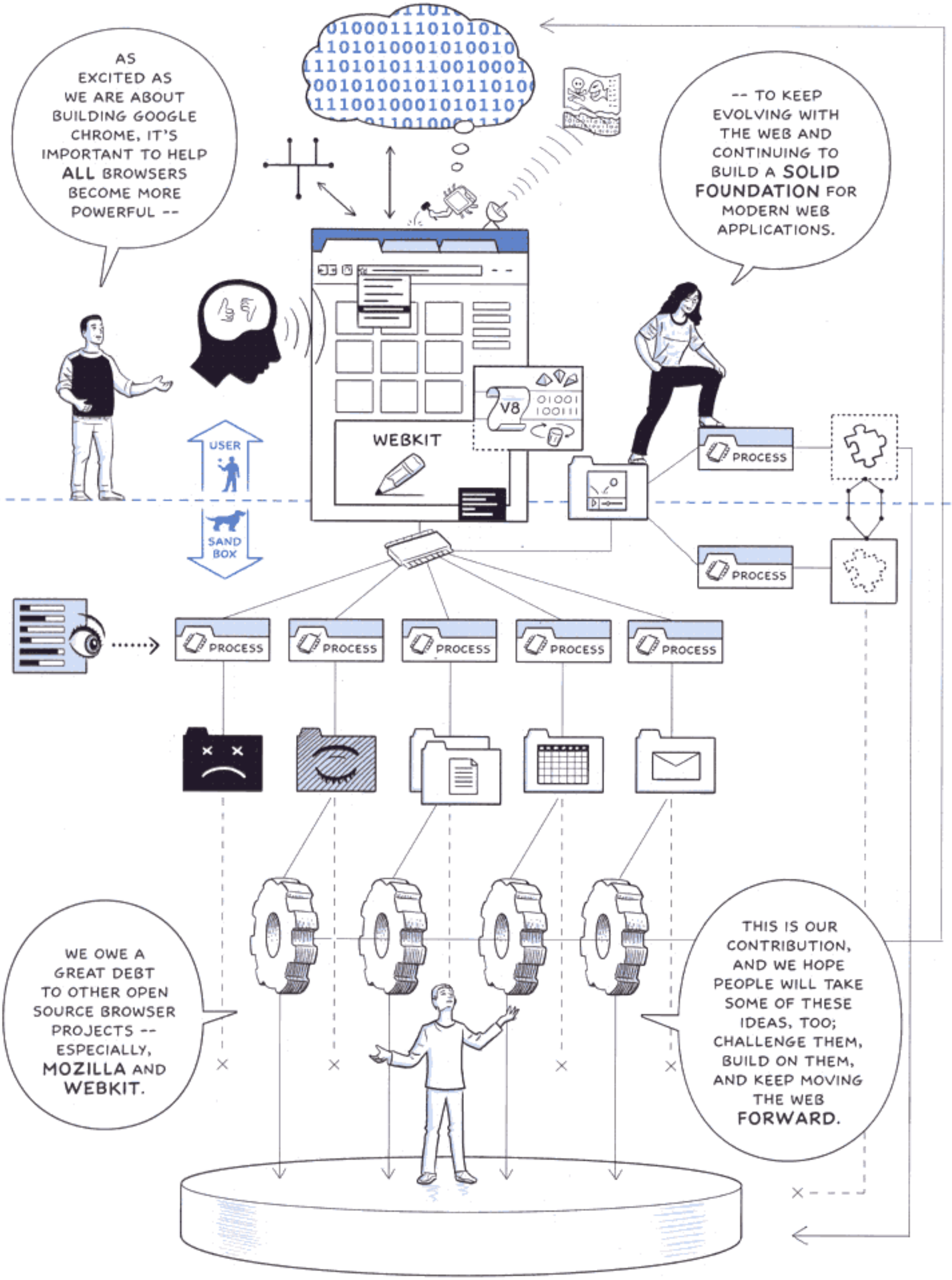
Chris DiBona,
Open Source Programs Manager



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






AS EXCITED AS WE ARE ABOUT BUILDING GOOGLE CHROME, IT'S IMPORTANT TO HELP ALL BROWSERS BECOME MORE POWERFUL --
-- TO KEEP EVOLVING WITH THE WEB AND CONTINUING TO BUILD A SOLID FOUNDATION FOR MODERN WEB APPLICATIONS.
WEBKIT
V8
USER
SAND BOX
PROCESS
PROCESS
PROCESS
PROCESS
PROCESS
PROCESS
PROCESS
WE OWE A GREAT DEBT TO OTHER OPEN SOURCE BROWSER PROJECTS -- ESPECIALLY, MOZILLA AND WEBKIT.
THIS IS OUR CONTRIBUTION, AND WE HOPE PEOPLE WILL TAKE SOME OF THESE IDEAS, TOO; CHALLENGE THEM, BUILD ON THEM, AND KEEP MOVING THE WEB FORWARD.

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