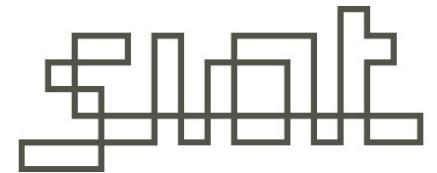

EFFICIENT AUTHORING OF RESIZABLE GRAPHICAL USER INTERFACES

VVISE



Wolfgang Stuerzlinger, vvise.iat.sfu.ca

SFU

PLETHORA OF SCREEN SIZES, 2 ORIENTATIONS

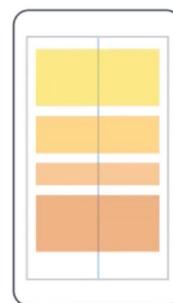


LAYOUT MODELS / PATTERNS

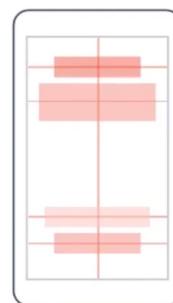
Resizeable GUIs

- Positioning & sizing
- Alignment & spacing
- Also, for localization

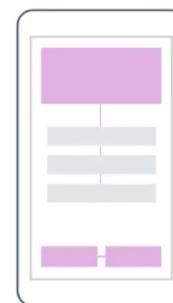
Web: flow layout



LinearLayout



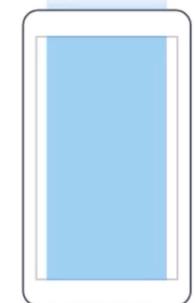
LinearLayout



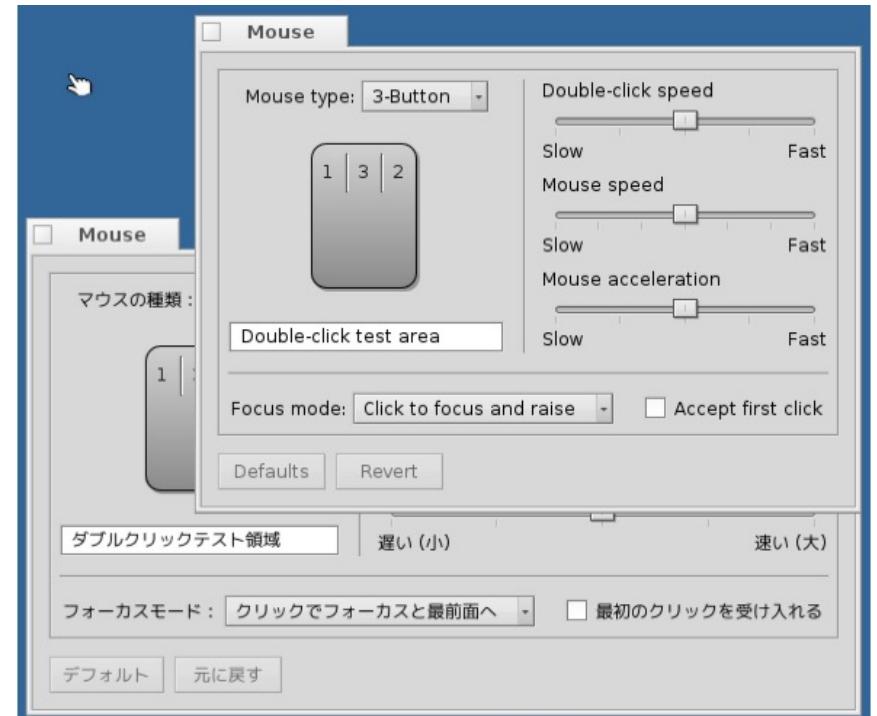
RelativeLayout



Grid



ScrollView



TOWARDS EFFICIENT RESIZABLE GUI CREATION



Overhead to
maintain GUI
consistency

Only
getting
worse



Designers
want/need
control

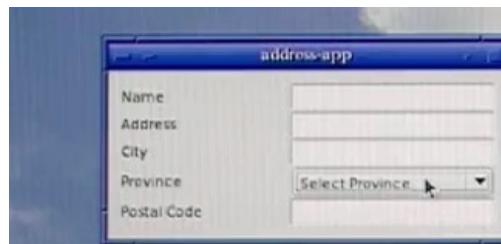
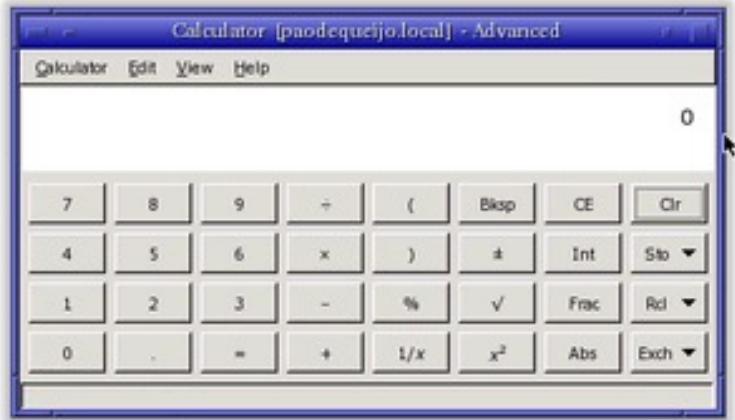
Aesthetics,
context, ...



Better layout
editors

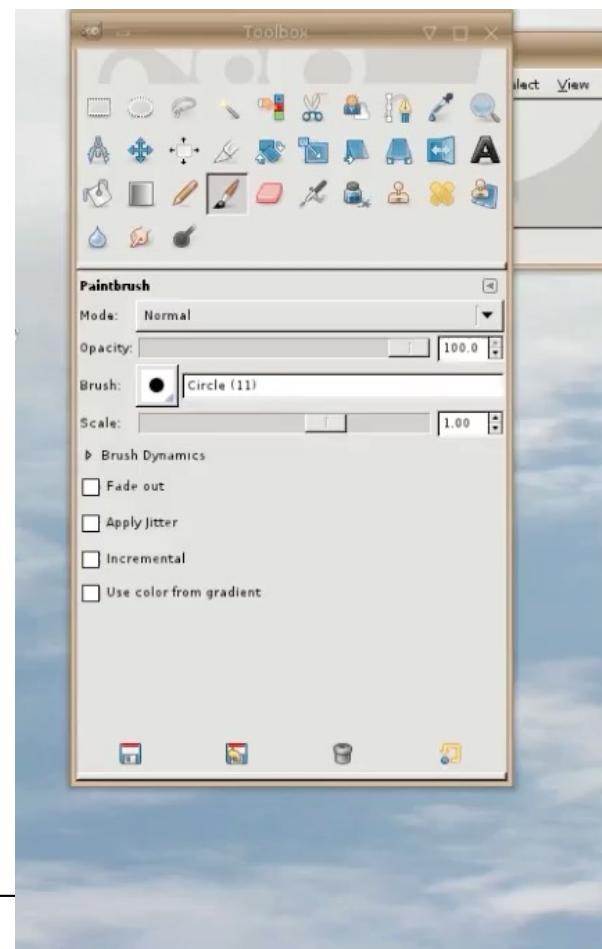
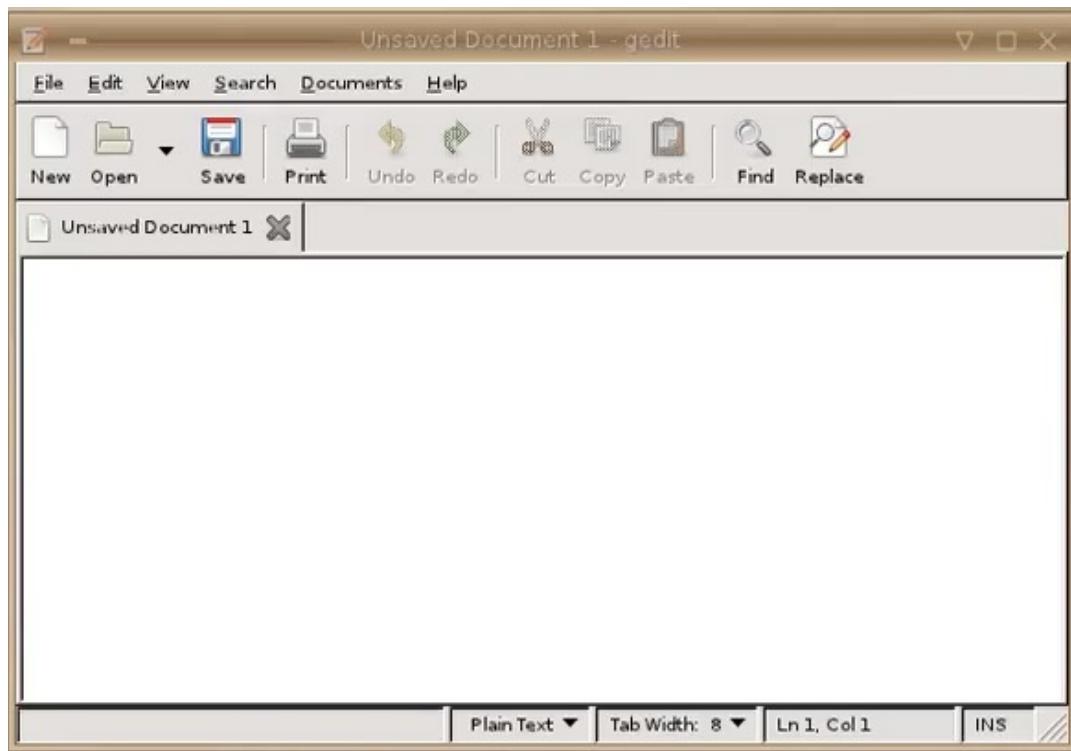
Ideally
GUI &
web

UI FAÇADES [UIST 06]

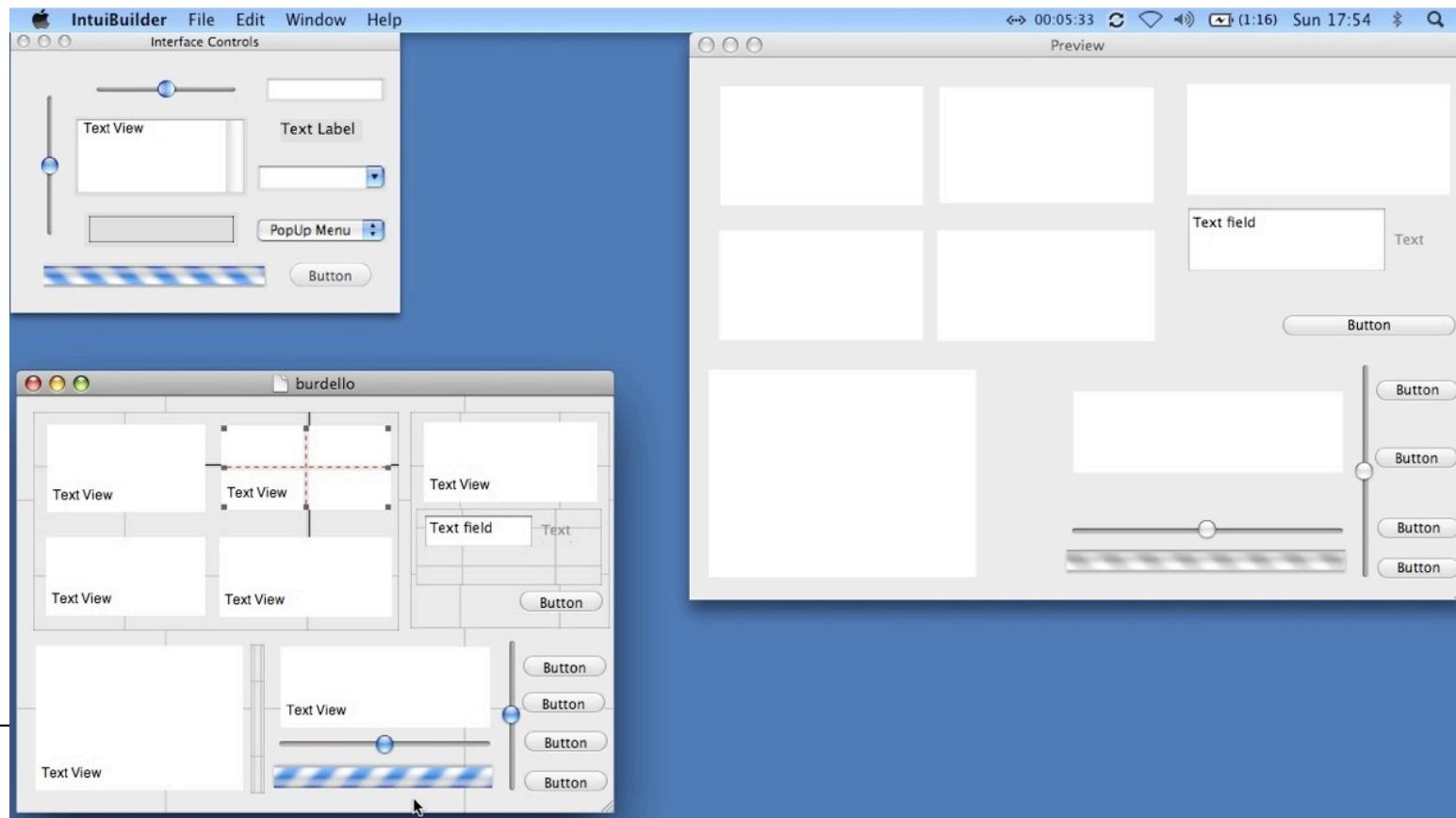


Widget
replacement

WIDGETLENS [AGARWAL 13]

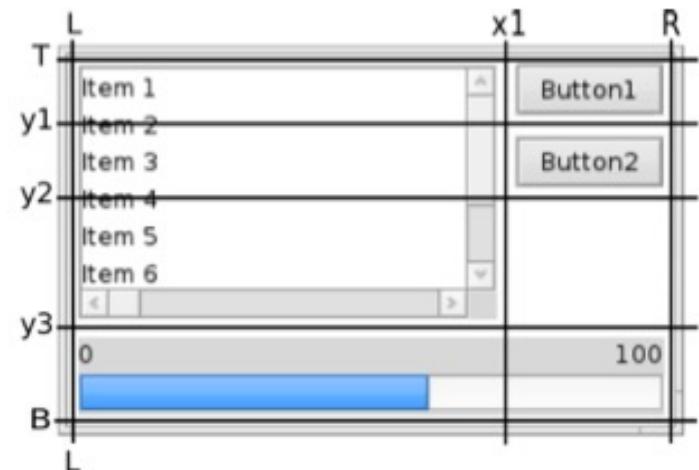


INTUI LAYOUT [SCODITTI 09]



CONSTRAINT-BASED GUI/WEB LAYOUT

- Superset of simpler layout models
- Linear constraints
 - Tabstop variables
 - But also, $x = 2 * y$
- Used in AutoLayout, CSS, ...



CONSTRAINT-SYSTEM SOLVER



Linear system

Cassowary



Quadratic cost function

Hard constraints (min size)

Soft constraints (pref size)

- Weights
-

CONSTRAINT-BASED LAYOUT - ISSUES

- Hard to author
- Cannot express flow layout
- Doesn't handle orientation well
 - No alternative layout
 - No swap of widgets
 - No dis-/appearing content
 - ...

Must See



Why China loves Tom Hiddleston's 'creepy' ad

How to Watch

BBC World News TV
The latest global news, sport, weather and documentaries

Listen Live

BBC World Service Radio
Stories from around the world



'We've marched 270 miles for Brexit'



Rare tiger cubs make debut at Sydney Zoo



Australian lake an Insta hit after turning naturally pink



Prodigy fans 'raise roof' at Keith Flint funeral



Quiz of the Week: Who's the 'culturally significant' rapper?

Most watched

1 ► Rare tiger cubs make debut at Sydney Zoo

2 ► First-time cover star at the age of 80

3 ► 'It's vital that children can see that people like me exist'

4 ► Why Trudeau's sorry for saying thank you

5 ► 'We've marched 270 miles for Brexit'

Full Story

ALE - AUCKLAND LAYOUT EDITOR (ALE) [ZEIDLER 13, UIST&INTERACT]

Drag & drop

- Most constraints automatically generated
- Guarantees solvable layout

Auckland Layout Editor
(ALE)

Clemens Zeidler (clemens@cs.auckland.ac.nz)
Christof Lutteroth (christof@cs.auckland.ac.nz)
Wolfgang Stuerzlinger (wolfgang@cse.yorku.ca)
Gerald Weber (gerald@cs.auckland.ac.nz)
Voice: Brenda Cerqueira

ALE - AUCKLAND LAYOUT EDITOR (ALE) [ZEIDLER 13, UIST&INTERACT]

Drag & drop

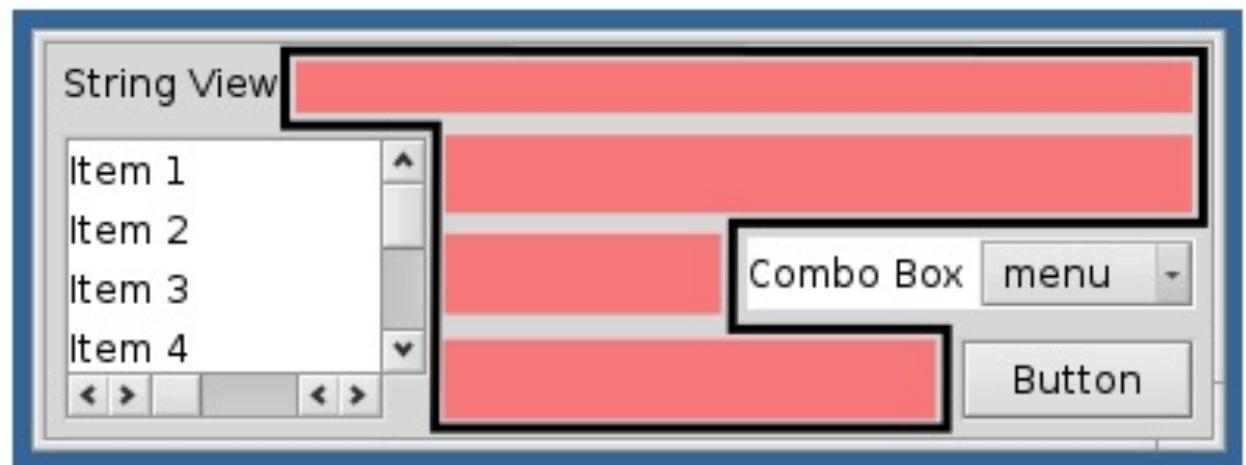
- Most constraints automatically generated
- Guarantees solvable layout

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Christof Lutteroth (christof@cs.auckland.ac.nz)
Wolfgang Stuerzlinger (wolfgang@cse.yorku.ca)
Gerald Weber (gerald@cs.auckland.ac.nz)
Voice: Brenda Cerqueira

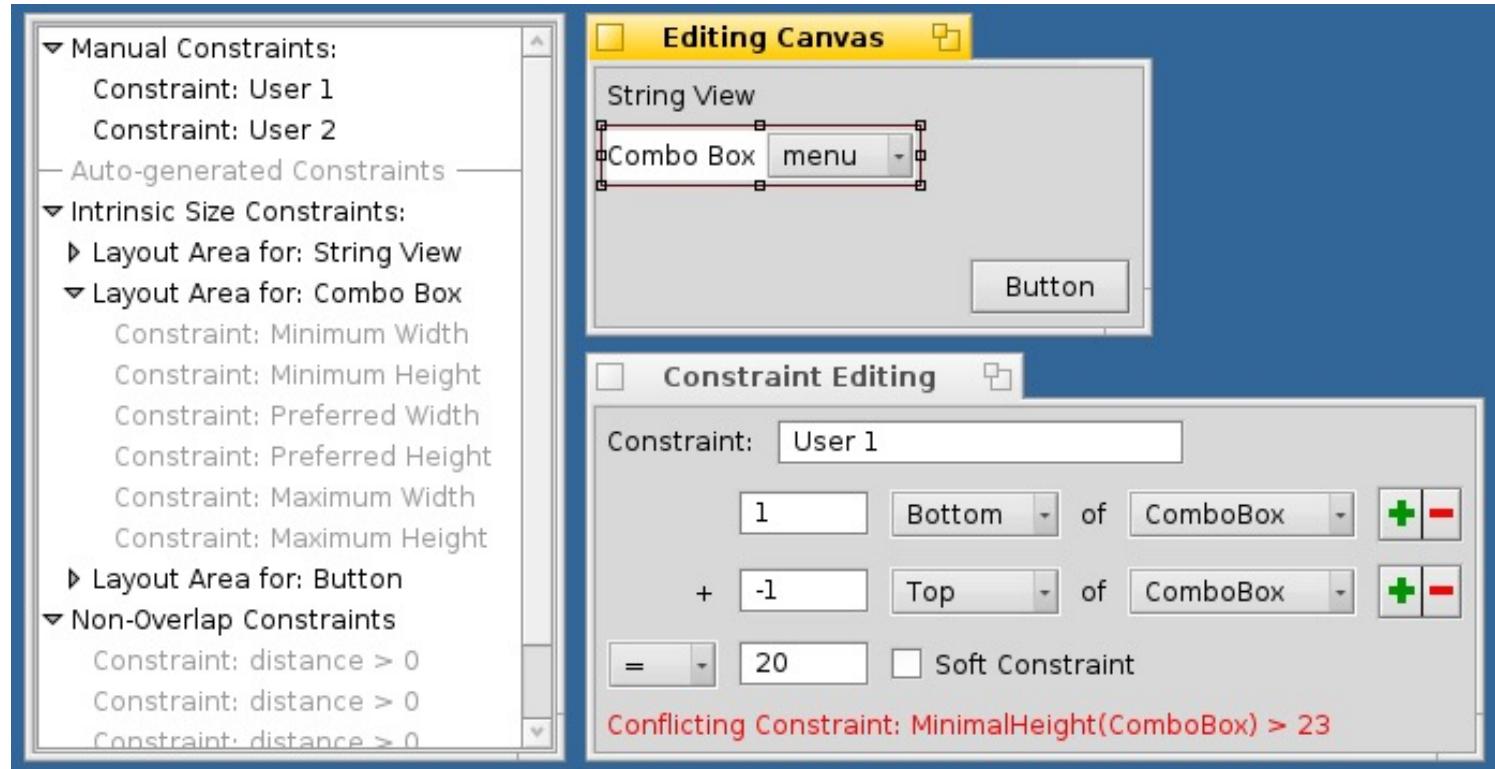
NON-OVERLAPPING LAYOUTS

- Empty space tiling
 - Avoid overlap due to missing constraints



AVOID CONSTRAINT CONFLICTS

- Check each constraint when added



OPTIMALLY SIZED PREVIEW

- Use minimum screen space to show issues

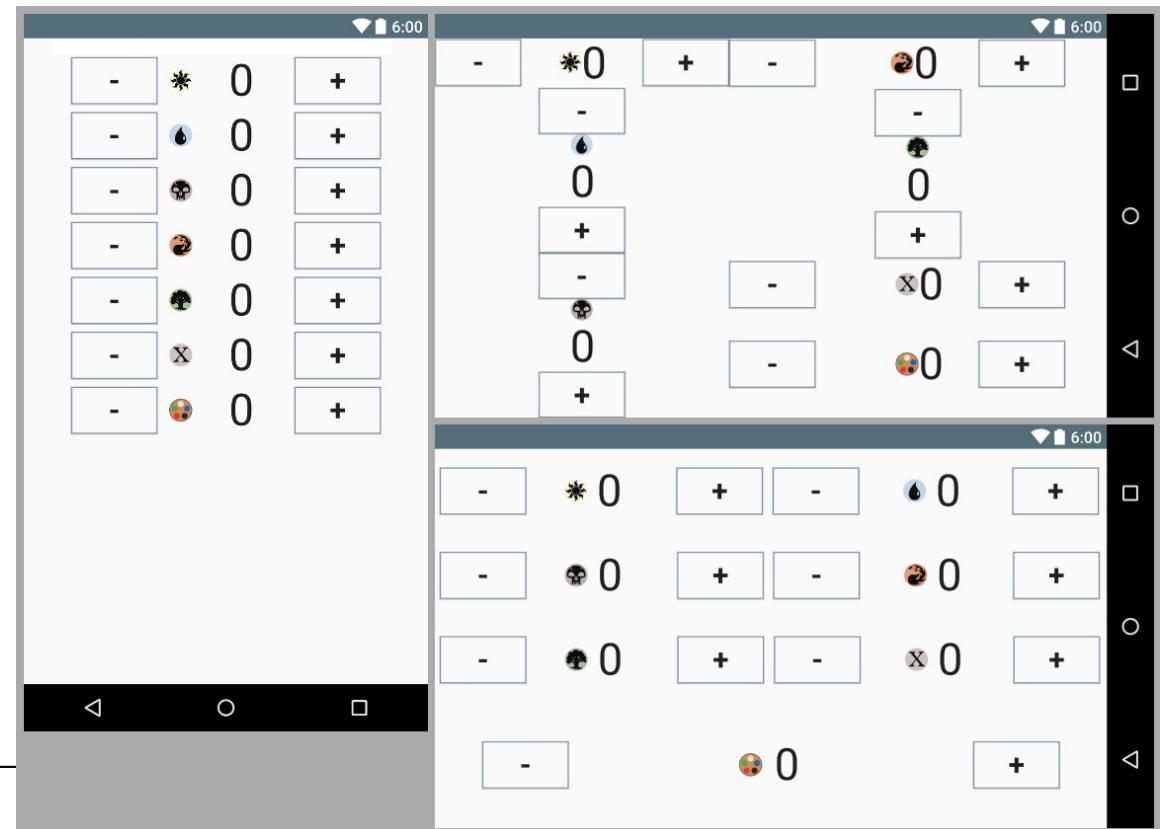
Auckland Layout Editor
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Wolfgang Stuerzlinger (wolfgang@cse.yorku.ca)
Gerald Weber (gerald@cs.auckland.ac.nz)
Voice: Brenda Cerqueira

AUTOMATIC GENERATION OF ALTERNATE LAYOUTS

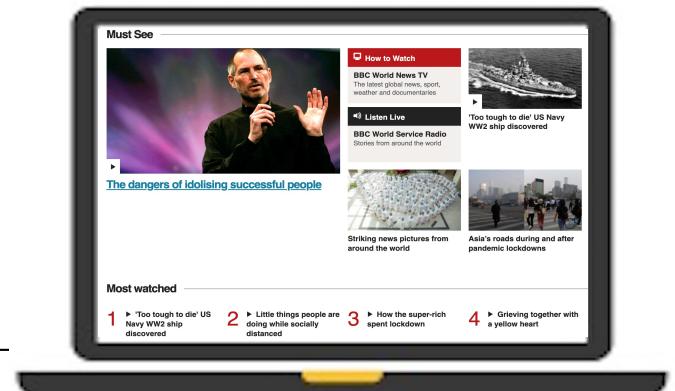
[ZEIDLER 17]

- Tiling algebra
 - Detect patterns in open-source Android Apps
- Display alternatives
 - User *toggles* alternatives
 - Minimum effort
- Outcome good start point



ORC LAYOUTS [JIANG 19 CHI]

- OR-constrained layouts
- Unifies constraint & flow layouts
 - Single layout specification for all screens

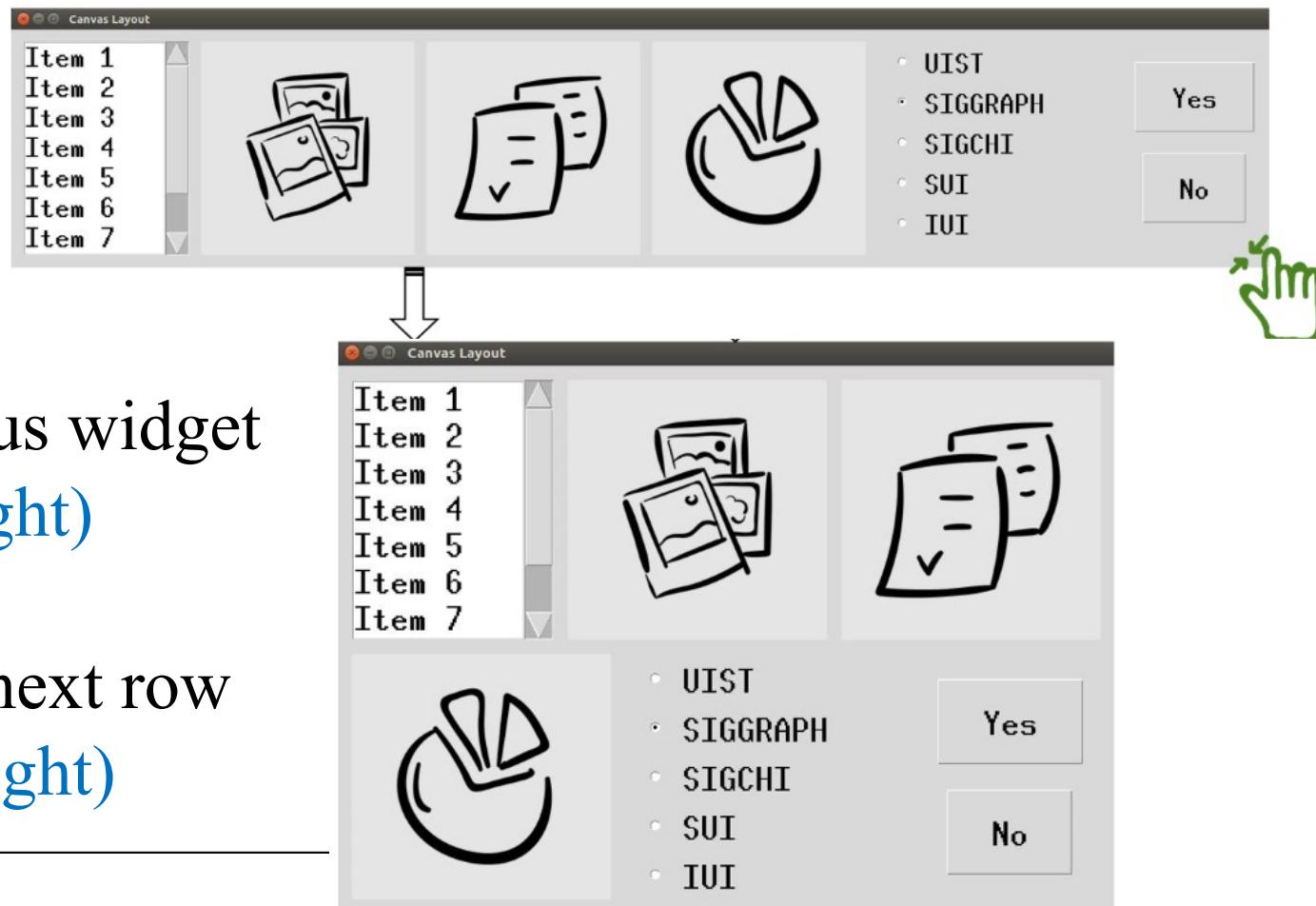


FLOW CONSTRAINT

to right of previous widget
(larger weight)

OR

at beginning of next row
(smaller weight)



OR-CONSTRAINTS

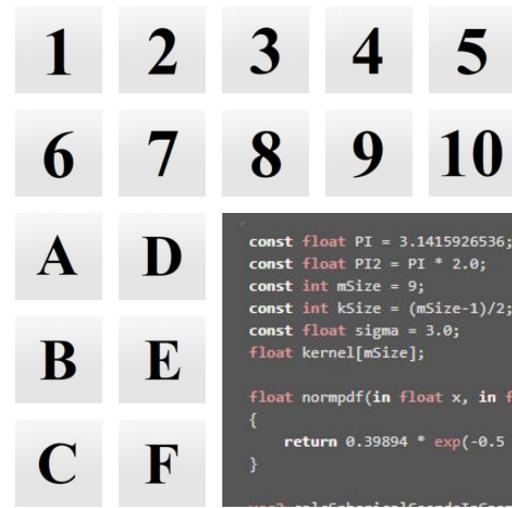
- Hard constraints must be satisfied
- Soft constraints are satisfied if possible
 - Their importance depends on weights

Constraint1 OR Constraint2 OR Constraint3 ...

Soft Soft Soft

Hard

ORC PATTERNS



```
const float PI = 3.1415926536;
const float PI2 = PI * 2.0;
const int mSize = 9;
const int kSize = (mSize-1)/2;
const float sigma = 3.0;
float kernel[mSize];

float normpdf(in float x, in float mu, in float sigma)
{
    return 0.39894 * exp(-0.5 * (x - mu) * (x - mu) / (sigma * sigma));
}
```

```
(assert (and (= w_1_1 b1) (= h_1_1 b3)))
(assert (and (<= w_1_2 b2) (<= h_1_2 b4)))
(assert (and (<= w_2_2 b2) (<= h_2_2 b4)))
(assert (and (<= w_3_2 b2) (<= h_3_2 b4)))
(assert (or (and (= w_2_1 (+ w_1_2 15)) (= h_2_1 h_1_1))
            (and (= w_2_1 15) (>= h_2_1 (+ h_1_2 15)) (= h_2_1 (+ h_1_2 15))
                  (>= h_3_1 (+ h_1_2 15))
                  (>= h_3_1 (+ h_2_2 15))
                  (or (= h_3_1 (+ h_1_2 15)) (= h_3_1 (+ h_2_2 15))
                      (or (= w_3_1 (+ w_2_2 15)) (= h_3_1 h_2_1)) a!1)))
            (assert (and (= b1 15) (= b2 475) (= b3 15) (= b4 475)))
            (assert (= (- w_1_2 w_1_1) (- b2 b1)))
            (assert (let ((a!1 (and (= (- w_2_2 w_2_1) 80) (>= (- (- b4 h_1_1)
                (a!2 (and (= (- w_2_2 w_2_1) 175) (< (- (- b4 h_1_2) 15)
                (or a!1 a!2)))
            (assert (= (- w_3_2 w_3_1) (- (- b2 w_2_2) 15)))
            (assert (= w_3_1 (+ w_2_2 15)))
            (assert (or (and (= (- h_1_2 h_1_1) 80) (>= (- b2 b1) 935))
                (and (= (- h_1_2 h_1_1) 175) (< (- b2 b1) 935)))
            (assert (= (- h_2_2 h_2_1) (- (- b4 h_1_2) 15)))
            (assert (= (- h_3_2 h_3_1) (- (- b4 h_1_2) 15)))
            (assert (= h_3_1 h_2_1))
            (assert-soft (= w_2_1 (+ w_1_2 15)) :weight 14900)
            (assert-soft (= h_2_2 h_1_2) :weight 1000)
            (assert-soft (= w_3_1 (+ w_2_2 15)) :weight 14800)
            (assert-soft (= h_3_2 h_2_2) :weight 1000)
```

- Designers choose template & modify parameters
- System maintains low-level constraints

SOLVING OR-CONSTRAINTS

- Linear system with OR terms
 - Huge solution space
- Z3 Theorem Prover
 - Interactive
 - Linear objective function

```
(assert (and (= w_1_1 b1) (= h_1_1 b3)))
(assert (and (<= w_1_2 b2) (<= h_1_2 b4)))
(assert (and (<= w_2_2 b2) (<= h_2_2 b4)))
(assert (and (<= w_3_2 b2) (<= h_3_2 b4)))
(assert (or (and (= w_2_1 (+ w_1_2 15)) (= h_2_1 h_1_1))
             (and (= w_2_1 15) (>= h_2_1 (+ h_1_2 15)) (= h_2_1 (+ h_1_2 15)))))
          (assert (let ((a!1 (and (= w_3_1 15)
                                (>= h_3_1 (+ h_1_2 15))
                                (>= h_3_1 (+ h_2_2 15))
                                (or (= h_3_1 (+ h_1_2 15)) (= h_3_1 (+ h_2_2 15))))))
                  (or (and (= w_3_1 (+ w_2_2 15)) (= h_3_1 h_2_1)) a!1)))
          (assert (and (= b1 15) (= b2 475) (= b3 15) (= b4 475)))
          (assert (= (- w_1_2 w_1_1) (- b2 b1)))
          (assert (let ((a!1 (and (= (- w_2_2 w_2_1) 80) (>= (- (- b4 h_1_2) 15) 555))
                        (a!2 (and (= (- w_2_2 w_2_1) 175) (< (- (- b4 h_1_2) 15) 555)))
                        (or a!1 a!2)))
                  (assert (= (- w_3_2 w_3_1) (- (- b2 w_2_2) 15)))
                  (assert (= w_3_1 (+ w_2_2 15)))
                  (assert (or (and (= (- h_1_2 h_1_1) 80) (>= (- b2 b1) 935))
                            (and (= (- h_1_2 h_1_1) 175) (< (- b2 b1) 935))))
                  (assert (= (- h_2_2 h_2_1) (- (- b4 h_1_2) 15)))
                  (assert (= (- h_3_2 h_3_1) (- (- b4 h_1_2) 15)))
                  (assert (= h_3_1 h_2_1))
                  (assert-soft (= w_2_1 (+ w_1_2 15)) :weight 14900)
                  (assert-soft (= h_2_2 h_1_2) :weight 1000)
                  (assert-soft (= w_3_1 (+ w_2_2 15)) :weight 14800)
                  (assert-soft (= h_3_2 h_2_2) :weight 1000)
```

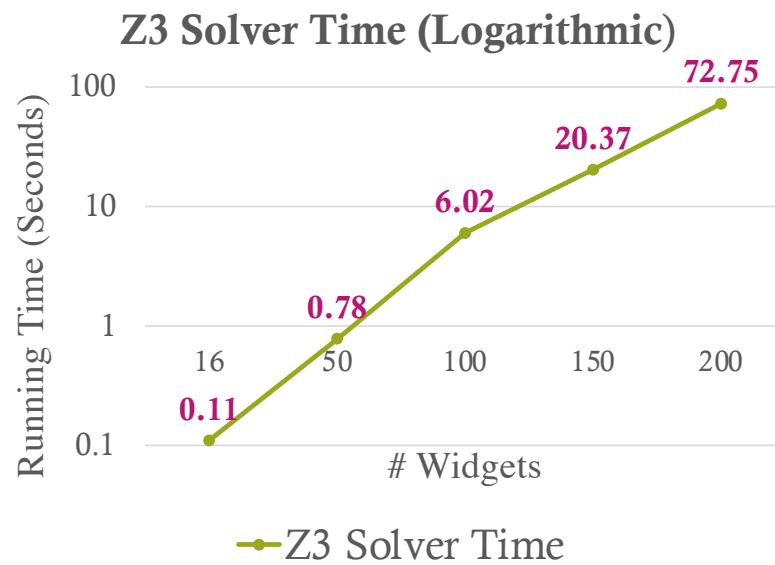
SOLVING TIME SCALABILITY



PhotoShop
25 widgets



GIMP
96 widgets

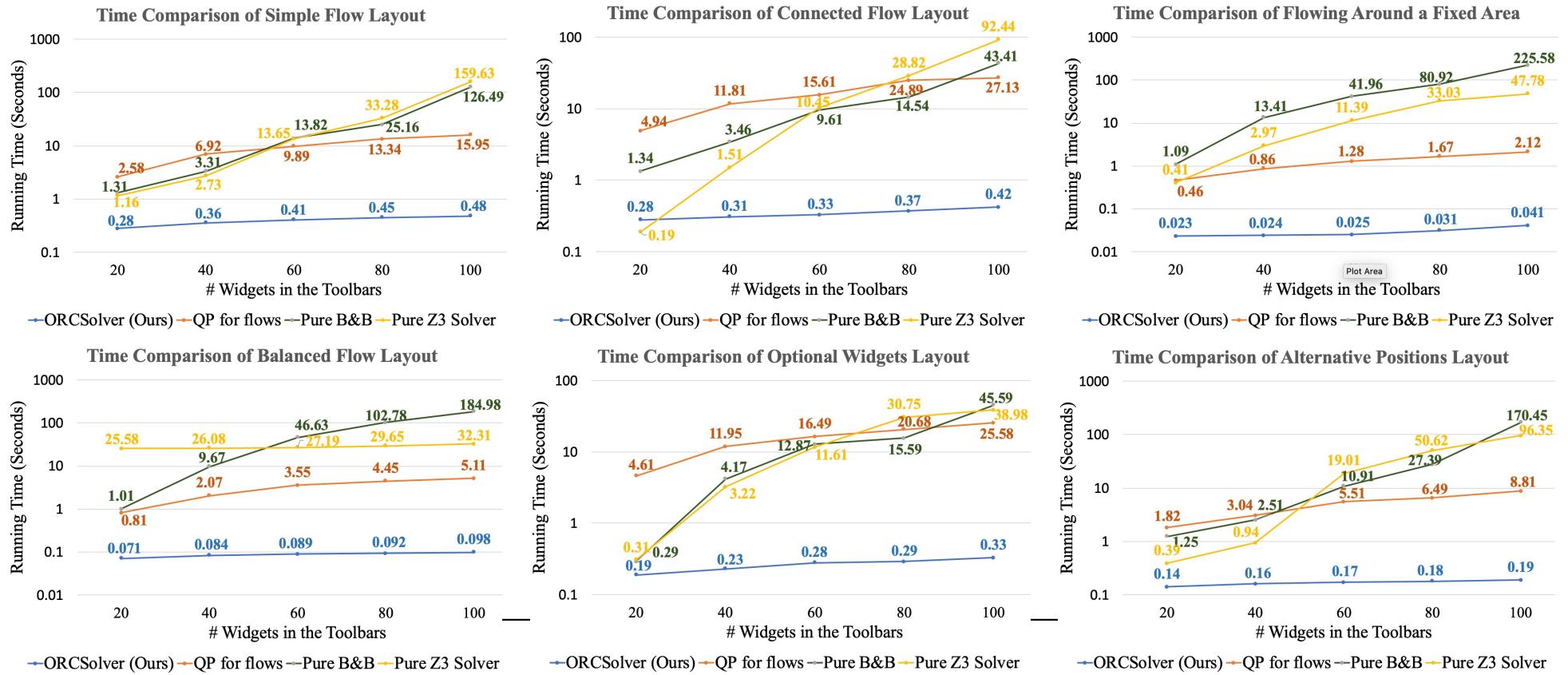


ORCSOLVER [JIANG 20 CHI]

- Branch-and-bound approach
 - Heuristic preprocessing
 - E.g., optimize for flows
 - Simplify specification
 - Discrete gradient search
 - Quadratic objective function
-



PERFORMANCE



GUI Toolkits



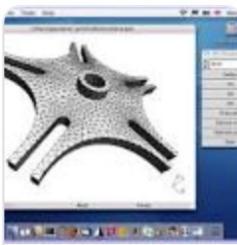
Qt
GNU Genera...



GTK
GNU Lesser ...



Tk
BSD licenses



FLTK
GNU Lesser ...



PyGTK
GNU Lesser ...



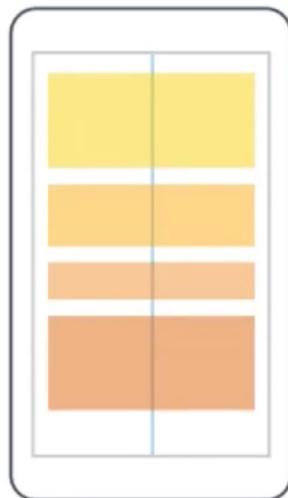
Standard
Widget Tool...
Eclipse Publ...



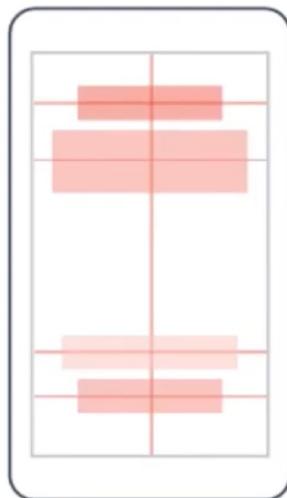
Swing



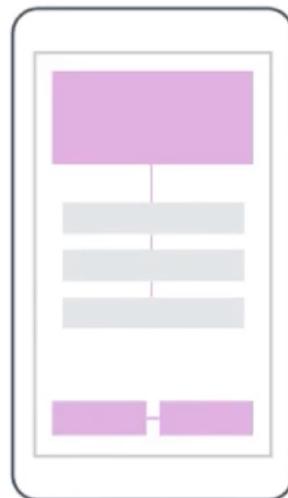
Motif
GNU Lesser ...



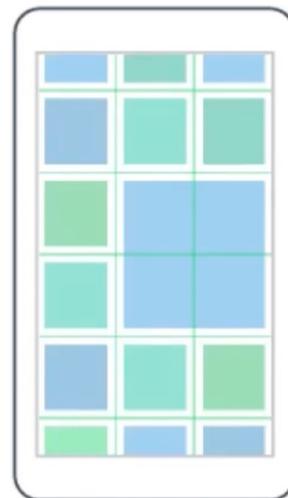
LinearLayout



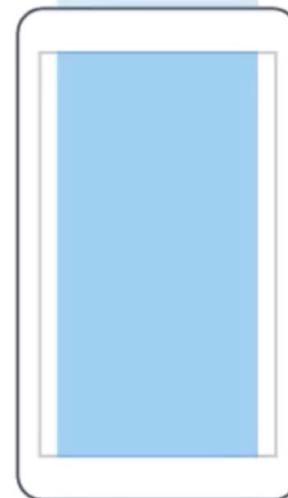
LinearLayout



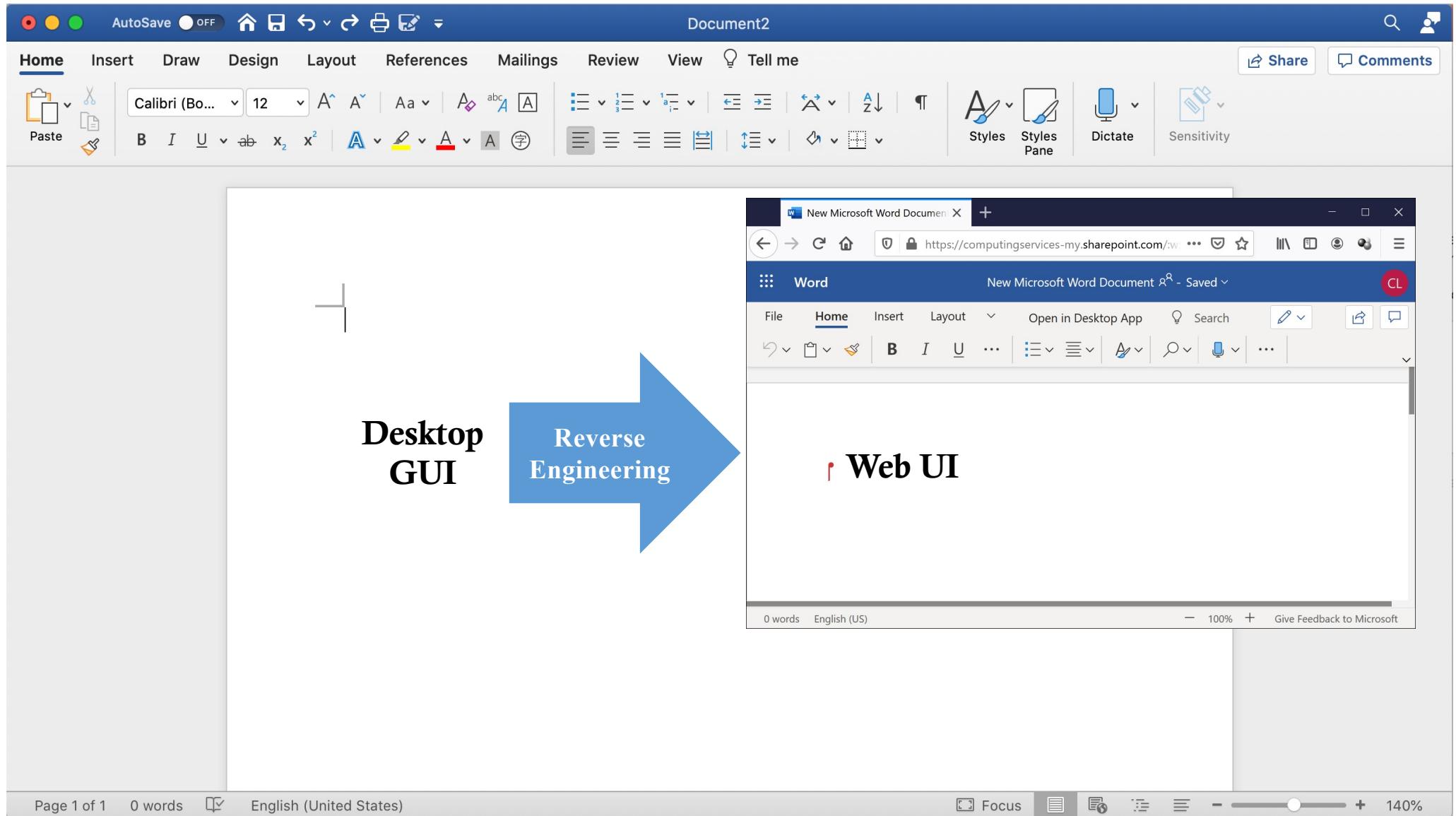
RelativeLayout



Grid

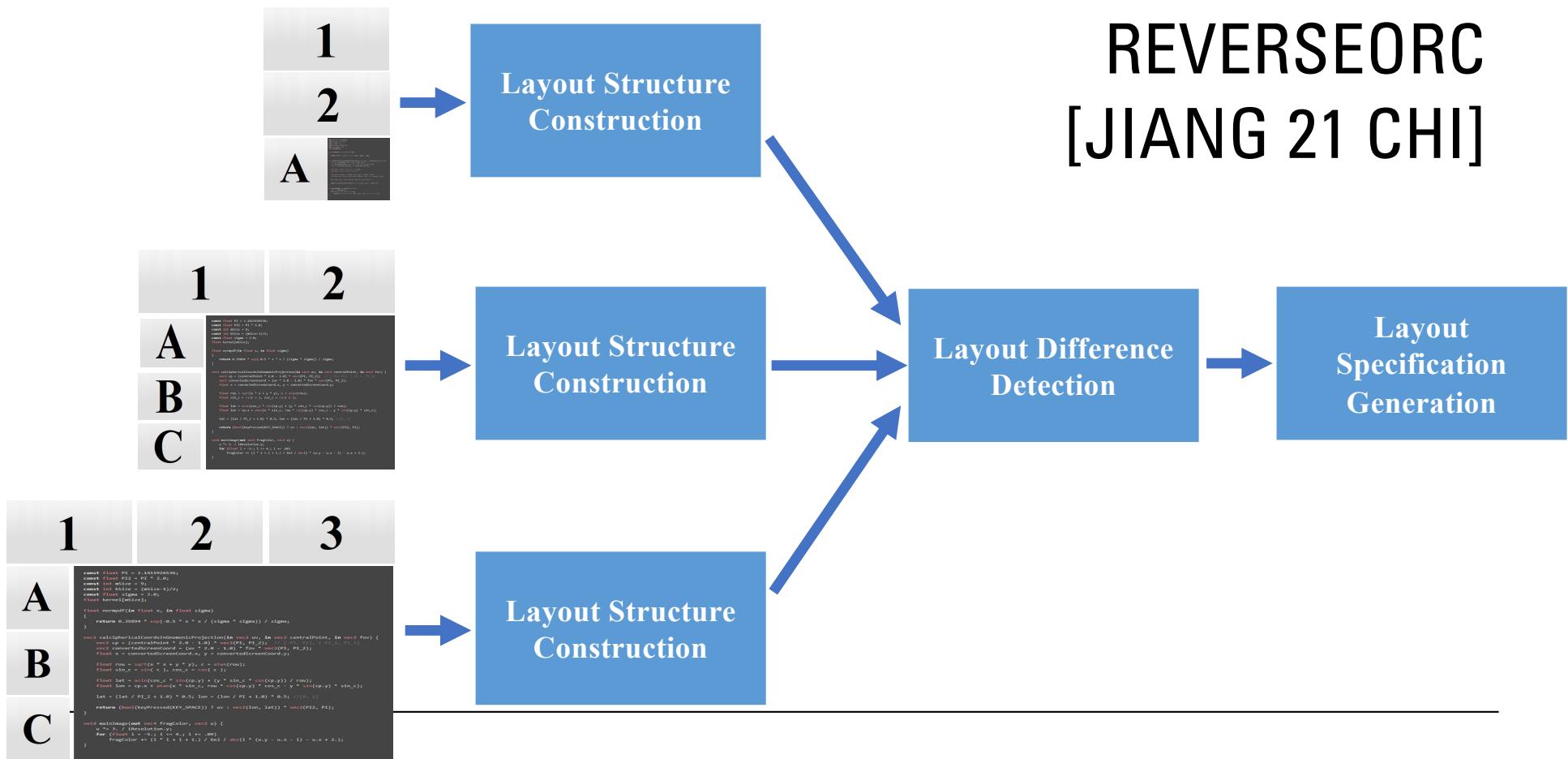


ScrollView



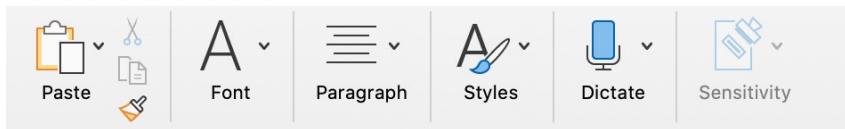
REVERSEORC

[JIANG 21 CHI]



GRID SEARCH SAMPLING

Min Size:



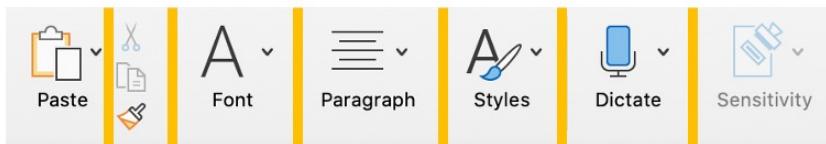
Subsampled Layout:



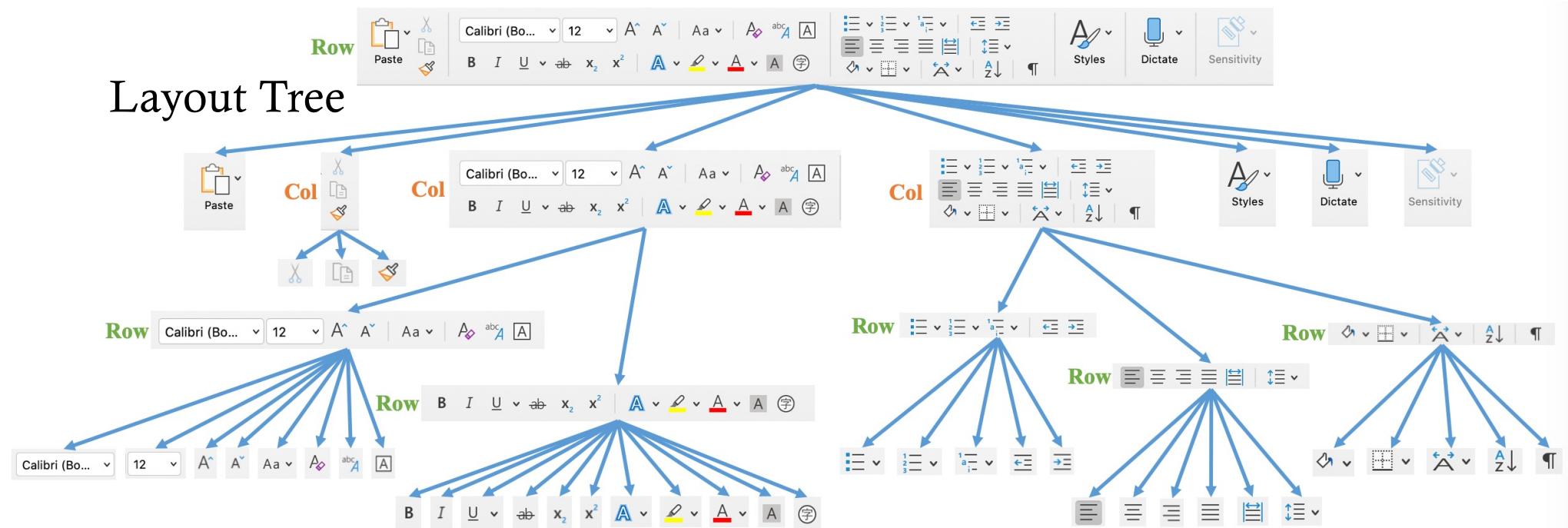
Max Size:



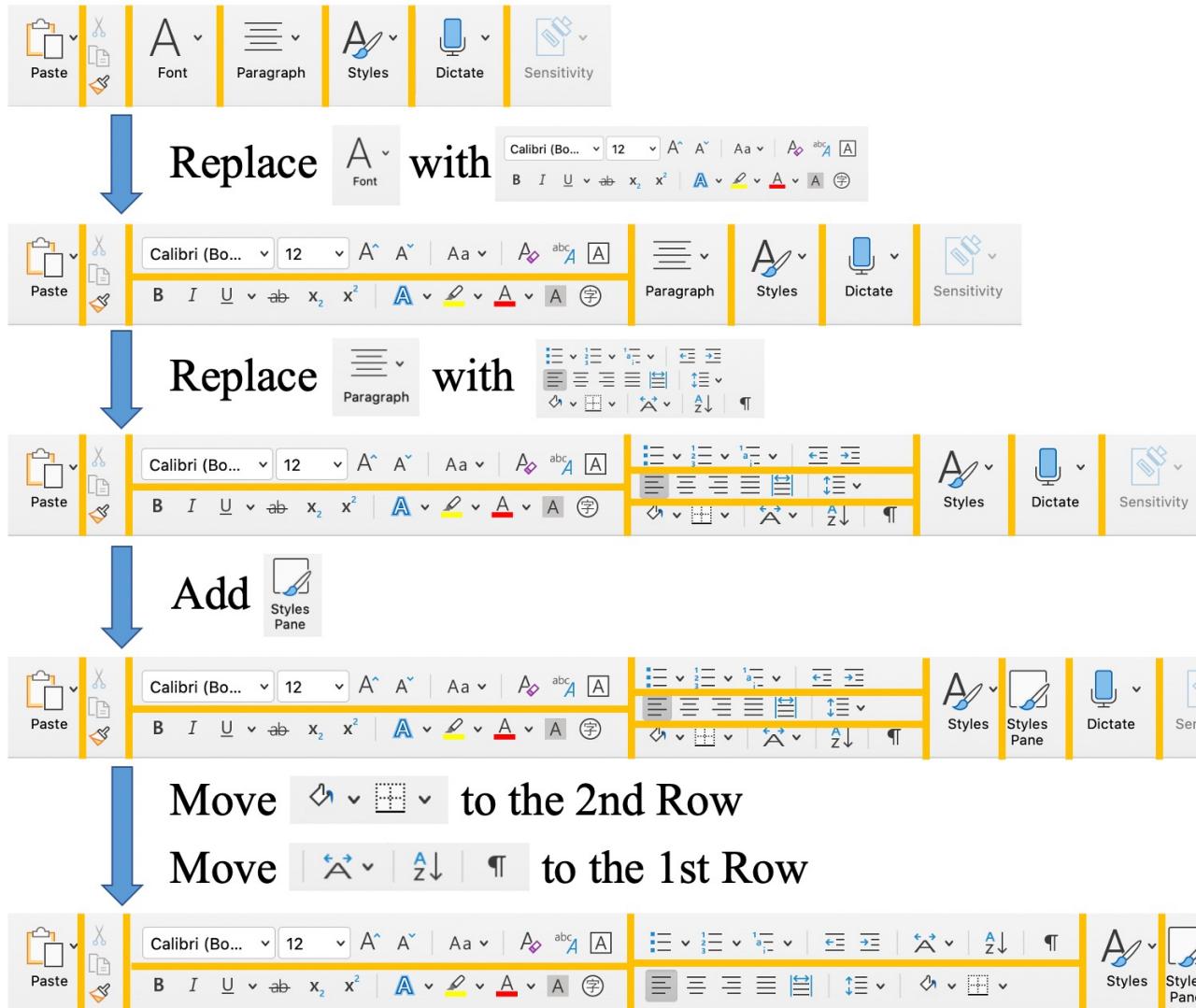
LAYOUT STRUCTURE RECONSTRUCTION



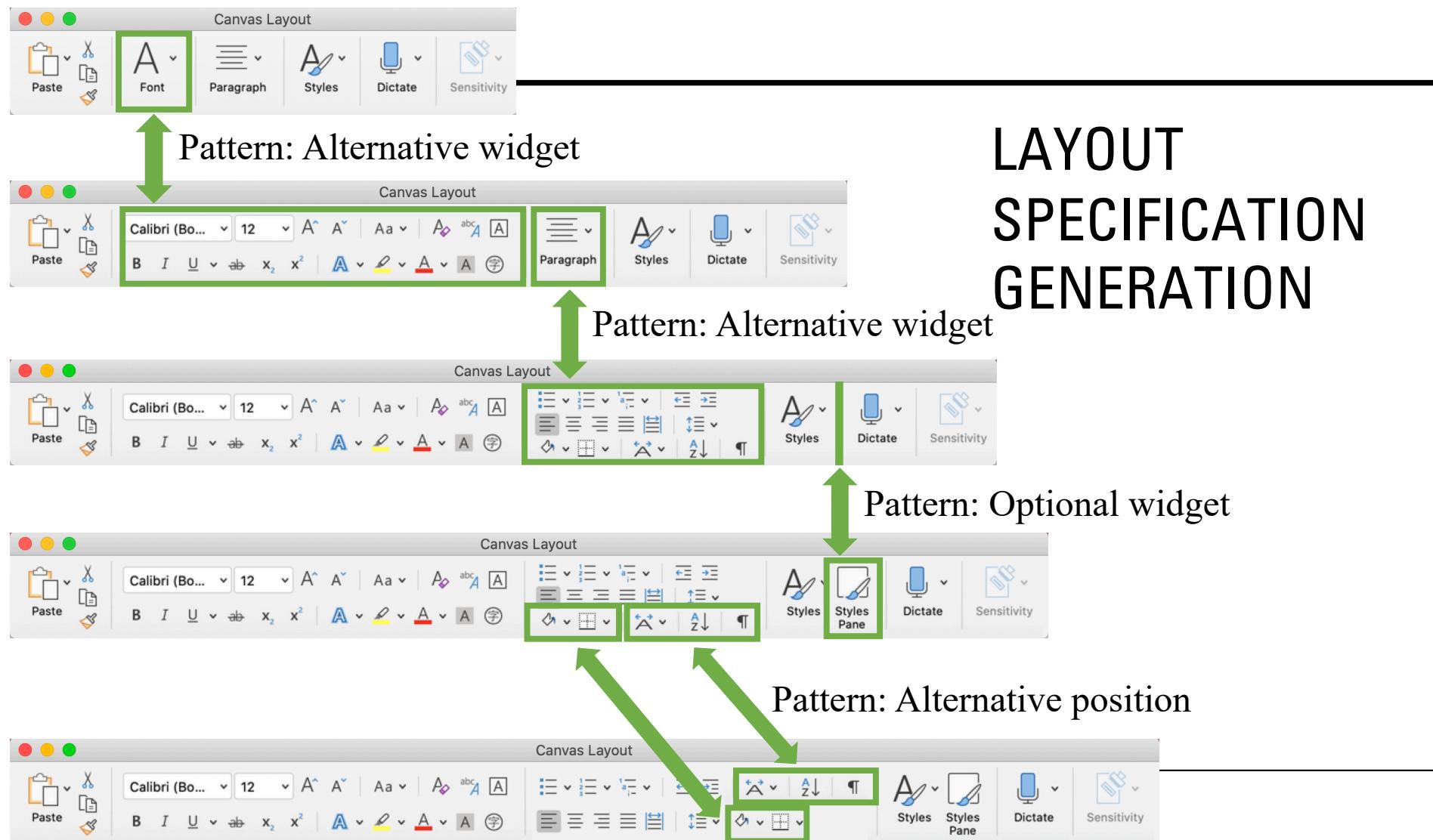
LAYOUT TREE RECONSTRUCTION



LAYOUT DIFFERENCE DETECTION



LAYOUT SPECIFICATION GENERATION

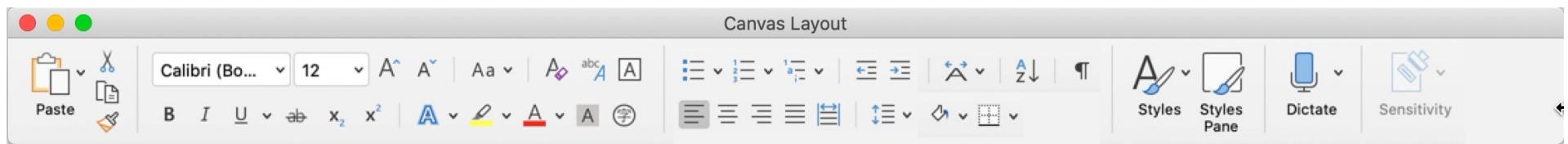


MS WORD RIBBON EXAMPLE

Original MS Word Ribbon:



Reverse-engineered result:



RECONSTRUCTED BBC NEWS

Canvas Layout

Belarus opposition keeps up anti-Lukashenko protest

At least 250 people are arrested, ahead of the latest of several weeks of mass protest.

5h | Europe

▶ Arrests as protests continue



- What's happening in Belarus?
- Europe's longest-serving ruler under fire

Two LA police officers shot in 'ambush'

Video of the incident shows a figure approach their vehicle, before opening fire and running away.

3h | US & Canada

US film Nomadland triumphs at Venice Film Festival

10h | Entertainment & Arts

US Open winner Osaka says a Covid break helped

17h | BBC Sport

Bloomberg donates \$100m for Biden in Florida

Donald Trump has hinted he will start spending his own money in the state that could swing the race.

2h | US Election 2020

Russia pols test Kremlin party's grip on power

1h | Europe

Man barred for tampering with eye prescriptions

10h | Australia

Israeli minister resigns over second lockdown

4h | Middle East

LeBron James leads LA Lakers to play-offs final

13h | BBC Sport

NFL week one - Newton scores first Patriots touchdown, plus more

- 2m Touchdown Washington
- 4m Touchdown Seahawks
- 7m Touchdown Lions

Brexit bill powers 'insurance policy' for UK

3h | UK Politics

MIXED PLATFORM EXAMPLE

Canvas Layout

The screenshot shows a desktop application window with a toolbar at the top containing icons for Paste, Calibri font, 12pt size, bold, italic, underline, superscript, subscript, and various styling options. The main content area features the CHI 2021 logo with the tagline "Making Waves, Combining Strengths". To the right is a photograph of a car driving through a hazy, smoke-filled area with power lines and an American flag in the background. Below the logo and photo are several news stories:

- Two LA police officers shot in 'ambush'**: Video of the incident shows a figure approach their vehicle, before opening fire and running away. (3h | US & Canada)
- Bloomberg donates \$100m for Biden in Florida**: Donald Trump has hinted he will start spending his own money in the state that could swing the race. (2h | US Election 2020)
- Wind warning prompts fears for US West Coast fires**: Gusts of up to 40 mph could lead to a further spread of fires in Oregon and northern California. (1h | US & Canada)
- US film Nomadland triumphs at Venice Film Festival**: (10h | Entertainment & Arts)
- US Open winner Osaka says a Covid break helped**: (17h | BBC Sport)
- South Korea's Covid detectives**: (20h | Asia)
- Russia polls test Kremlin party's grip on power**: (1h | Europe)
- Man barred for tampering with eye prescriptions**: (10h | Australia)
- Israeli minister resigns over second lockdown**: (4h | Middle East)
- LeBron James leads LA Lakers to play-offs final**: (13h | BBC Sport)
- LIVE NFL week one - Newton scores first Patriots touchdown, plus more**:
 - 2m Touchdown Washington
 - 4m Touchdown Seahawks
 - 7m Touchdown Lions(3h | UK Politics)

FUTURE PLANS

Unify GUI & web layout further

Explore more complex layout problems

Improved GUI editors

Integrate suggestions from ML

THANKS

Students

- B. Agarwal, D. Phillips,
N. Mohaghegh, A. Scoditti,
Y. Jiang, ...

Collaborators

- *C. Lutteroth, C. Zeidler,*
G. Weber, M. Zwicker,
O. Chapuis, N. Roussel, ...

