Distributed Control of LED Array for Architectural and Signage Lighting

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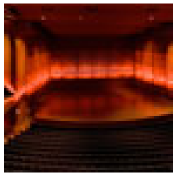
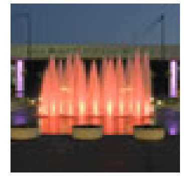
LED Lighting Installations

Recent Lighting Installations


Alice Tully Hall at the Lincoln Center for Performing Arts


Avenue of the Arts

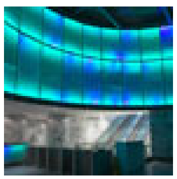

Carré de Soie


City of Long Beach

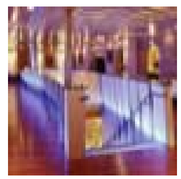

County Hall

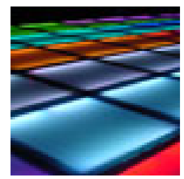

First Baptist Church

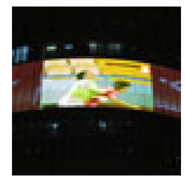
All Architectural Lighting Installations


111 Buckingham Palace Road

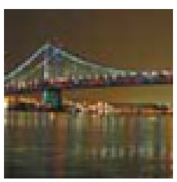

27 Knightsbridge

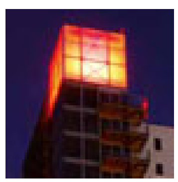

33 Restaurant & Lounge

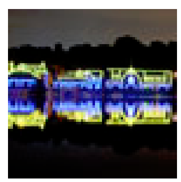

Amara Beach Resort Hotel

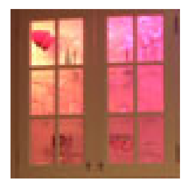

Aspire Tower

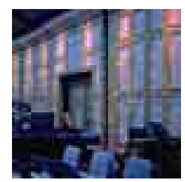

Bangkok Kitchen

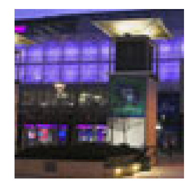

Ben Franklin Bridge

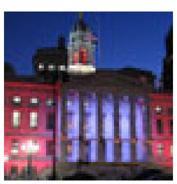

Berkeley Homes Tower at Tabard Square

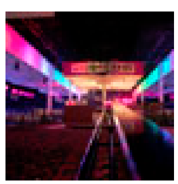

Boathouse Row

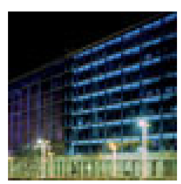

Boston Residence

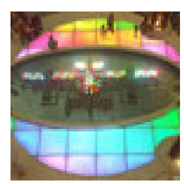

Boston Symphony Hall

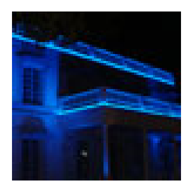

Bristol Harbourside Lightwall


Brooklyn Borough Hall, Con Edison


Brunswick Zone


Caisse Des Depots Et Consignation


Capitol Mall


Casa Grijalva


Casino Niagara

“the big picture” IEEE Spectrum April 2010

- From 7:00 to 9:30 each evening from 30 January through 18 March, visitors to Xuanwu Lake Park in Nanjing, China, were able to see this and other breathtaking works of art. The ornate structure, which looks like it’s composed of painstakingly wrought stained-glass panes, is actually one of 75 exquisitely detailed replicas of Italian landmarks, made up of a total of 560 000 LEDs. They’re all part of the Italian International Light Sculpture Art Festival, which was timed to coincide with the Chinese New Year.

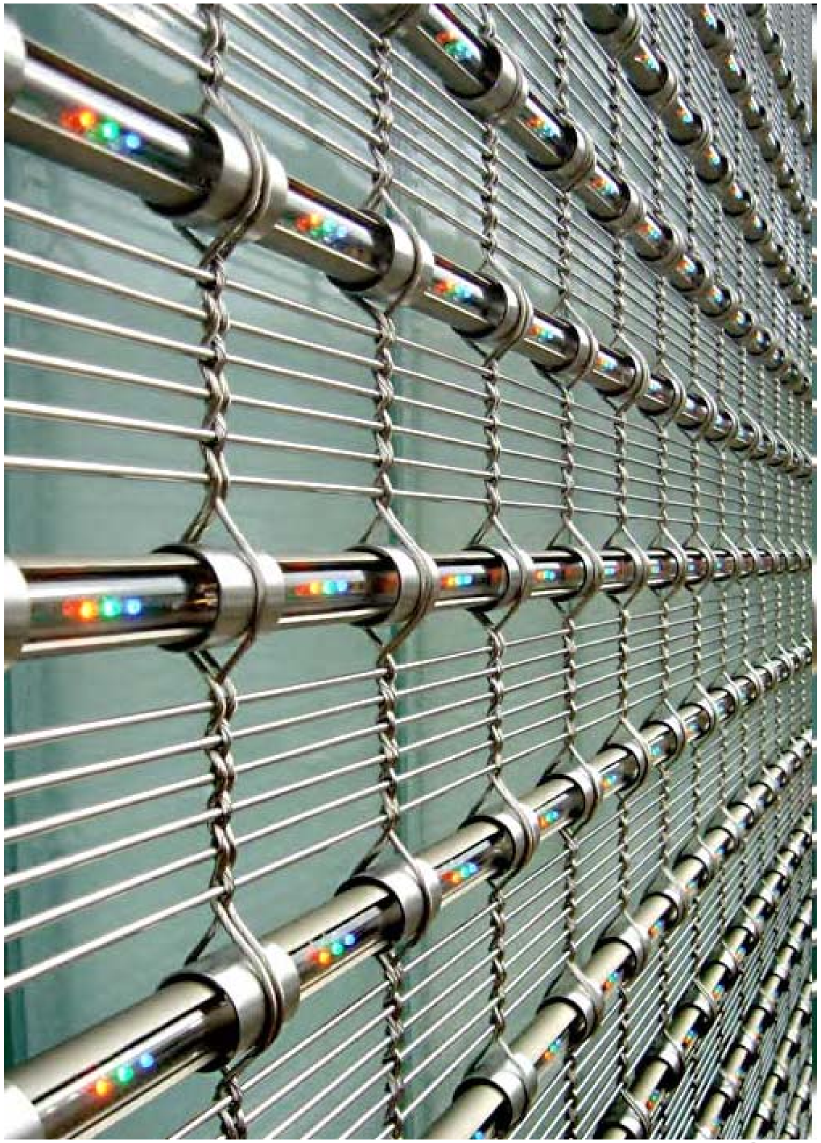
LED Light Tunnel

- National Gallery of Art in Washington DC, “LED light tunnel”
- “The custom designed software also has an element of chance built into it, so it’s unlikely that anyone will see the same routine twice.”

GreenPix, China

- GreenPix – Zero Energy Media Wall
  - uses thousands solar photovoltaic capture cells
  - an array of **computer-controlled LEDs**.
  - constructed for visitors attending the 2008 Beijing Olympics,
  - located in the Xicui entertainment complex, near the site of the games.

The Grand Indonesia Tower (Jakarta, Indonesia.)



Media Facades Festival

Takarazuka University Of Art And Design,Osaka

Power Station, Brussels

Rockefeller Center, NY

More

Further more

1 more

Question – control methods and wiring?

- **Architecture and Form**
  - **Mechanical/Thermal Interface**
  - **Electrical Interface**
  - **Communications and Control Interfaces**

Takarazuka University Of Art And Design,Osaka

Products Used:

New
For Facade
174 ColorBlast

124 iColor Cove 12" (now specified using iColor Cove QLX)

cMOPS-150

iMOPS-150

LIMITED QUANTITY
For Exterior Sign
229 iColor Cove 6"

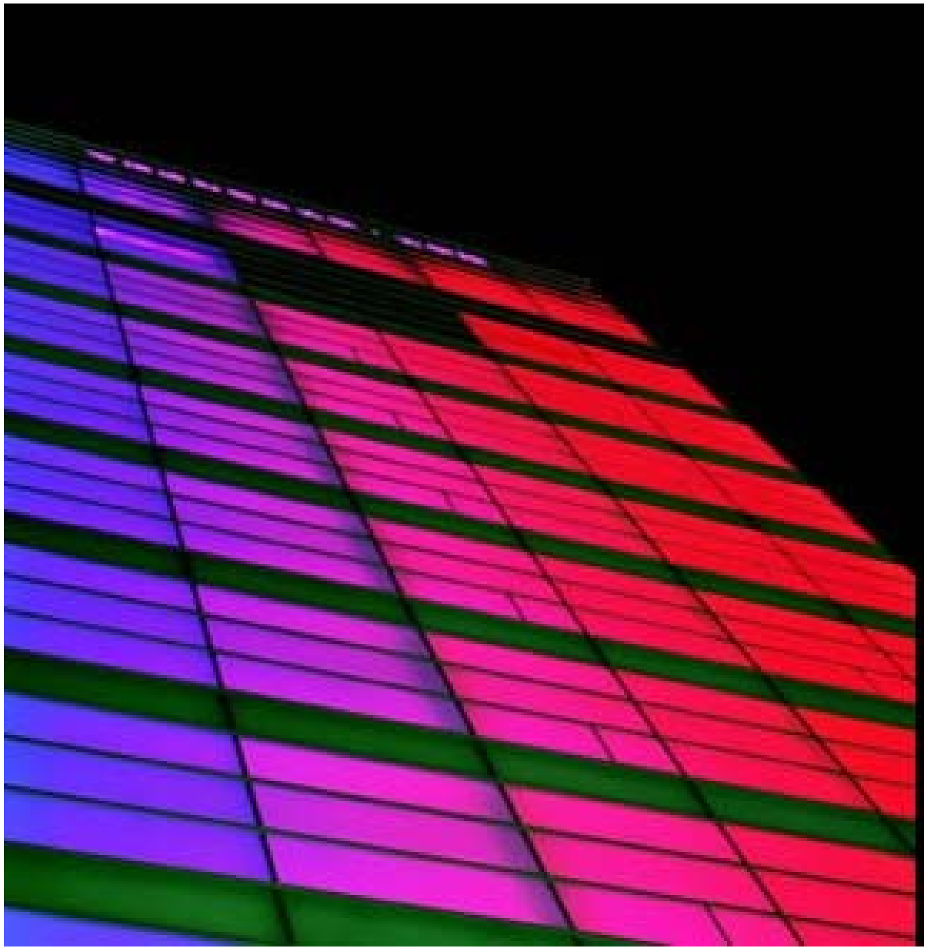
New
cMOPS-150

iMOPS-150

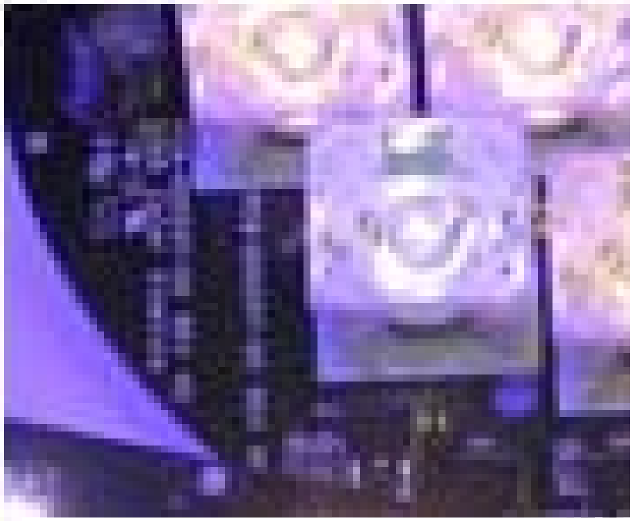
Method of Control:

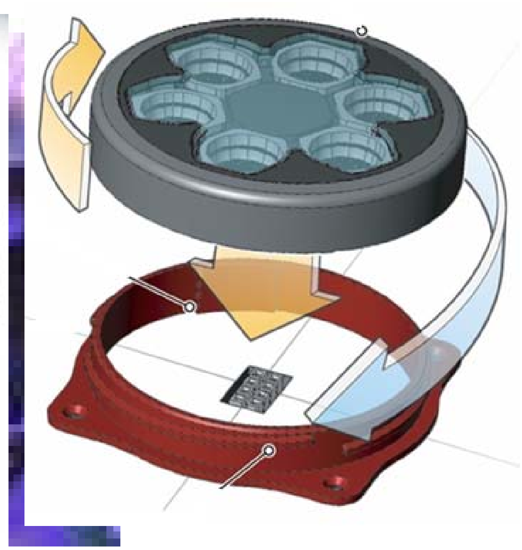
To Be Replaced
iPlayer 2 (now specified with iPlayer 3)

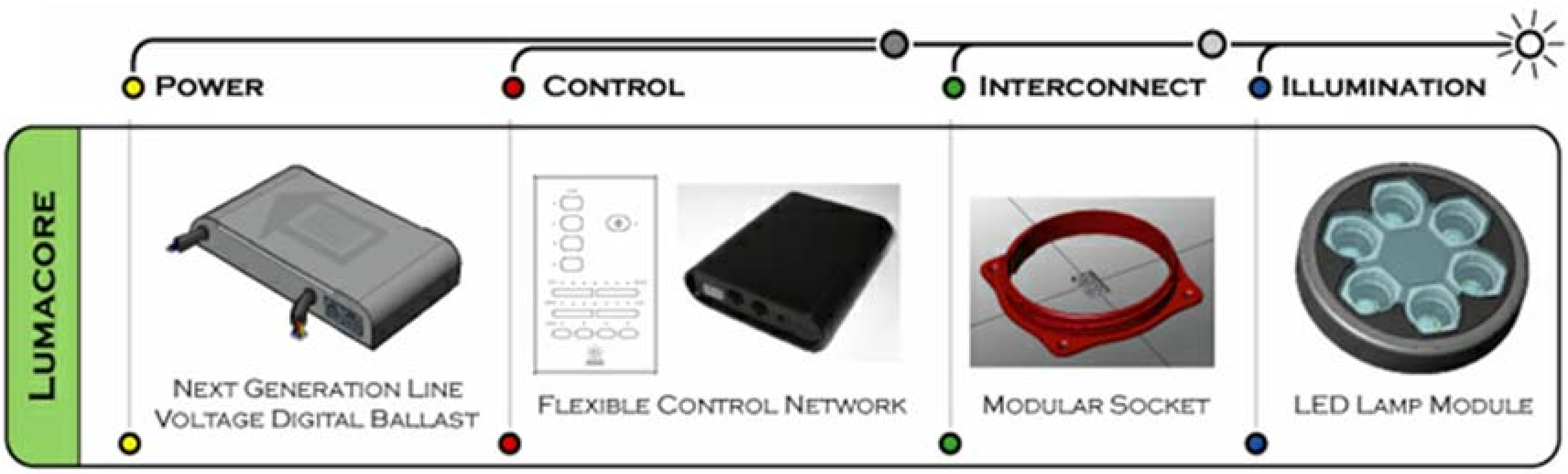
DMX Controller



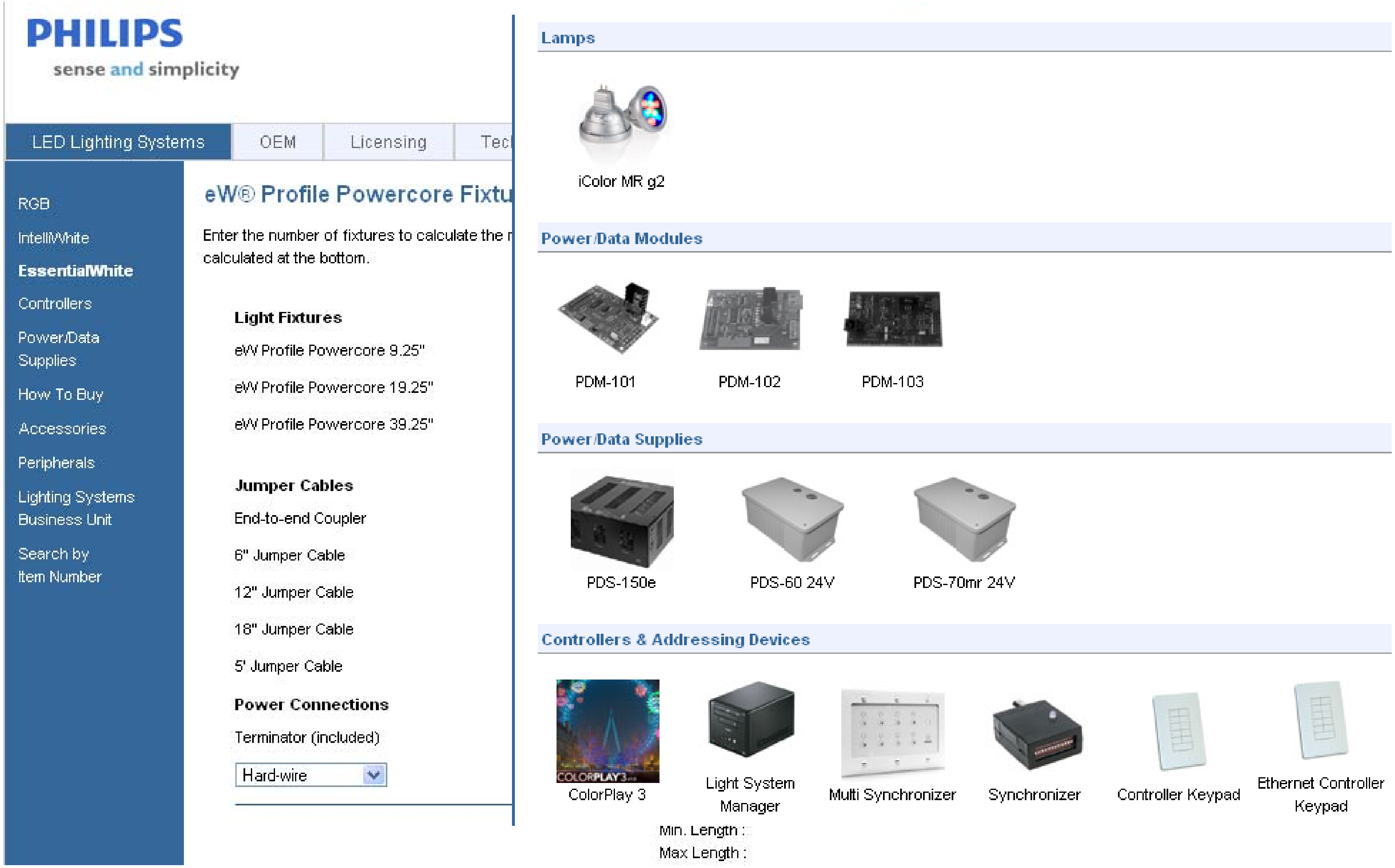
LED Lighting System



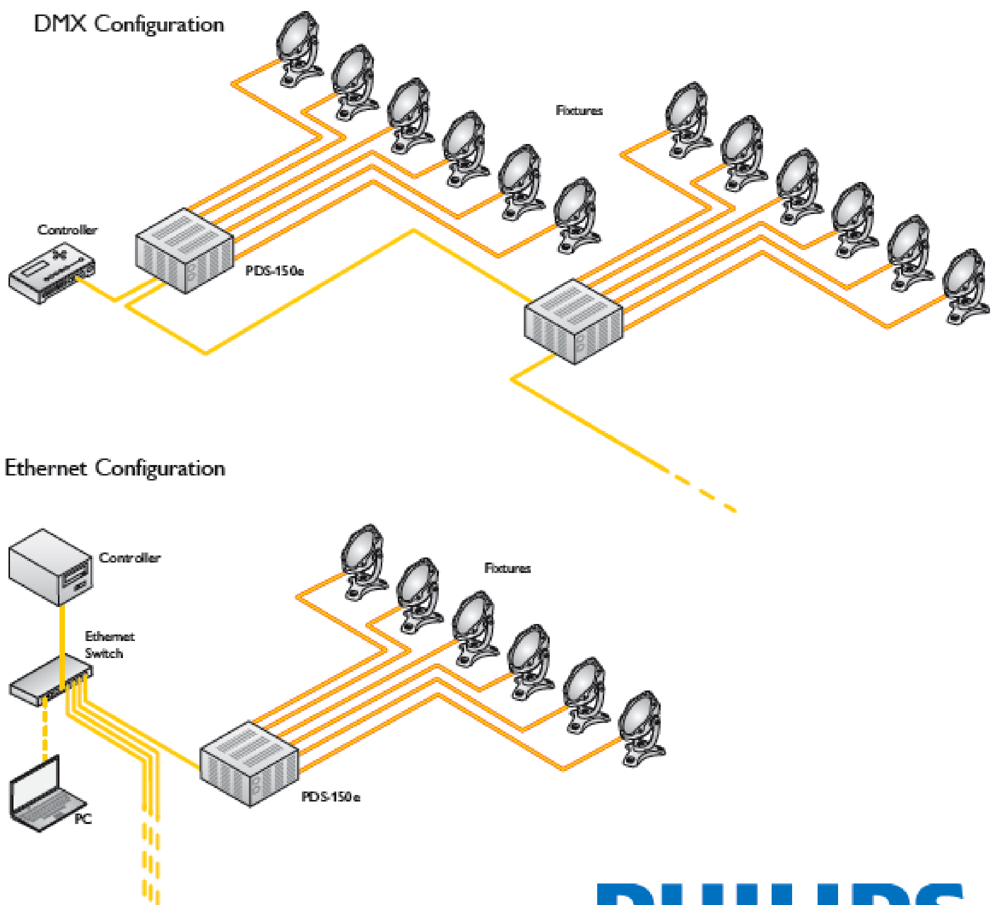


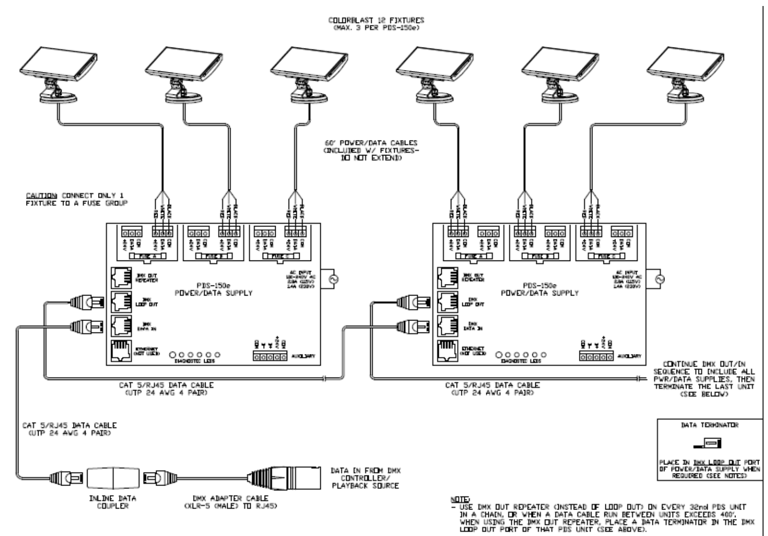


Components for Lighting Control



Centralized Lighting Control System

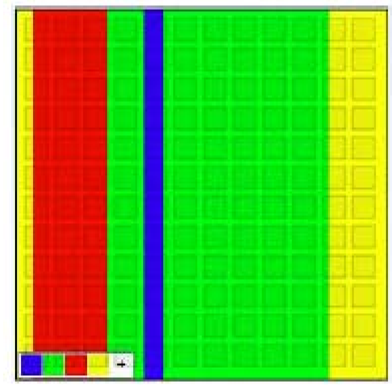


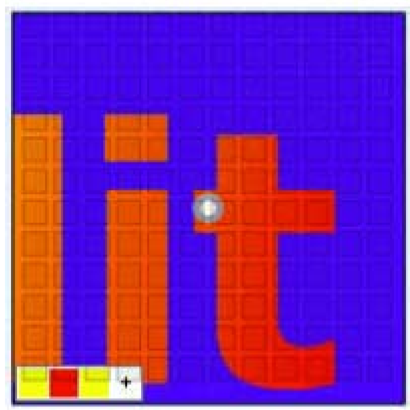


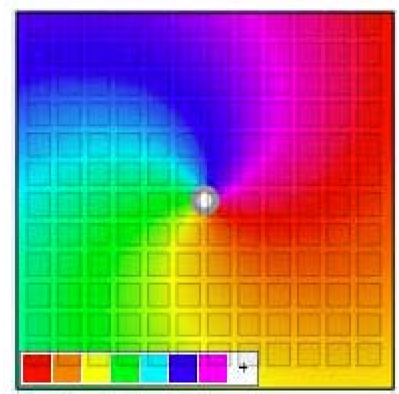
PHILIPS

Centralized Lighting Control

- Advantage:
  - Synchronized/Asynchronized and Complete Control
- Disadvantage:
  - Controllers
  - Synchronizers
  - Control Wires
  - Installation
- An Alternative Way?
  - Cellular Automata





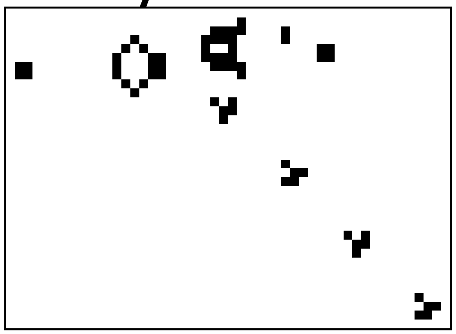


Models of Natural Systems

- Mathematical Basis
  - Differential equations:
    - most current
    - Suitable for systems with a small number of continuous degrees of freedom, evolving in a continuous manner
  - **Cellular Automata**:
    - alternative, complementary basis for mathematical models
    - Describes the behaviors of systems with large numbers of discrete degrees of freedom
    - "CA are mathematical idealizations of physical systems in which space and time are discrete, and physical quantities take on a finite set of discrete values.

Fundamental Characteristics of CA

- They consist of a discrete lattice ("array") of sites ("cells")
- They evolve in discrete time steps
- Each site takes on a finite set of possible values
- The value of each site evolves, simultaneously, according to the same deterministic rules
- The rules for the evolution of a site depend only on a local neighborhood of sites around it.
- Example: John Conway's "Game of Life"



Origin of CA

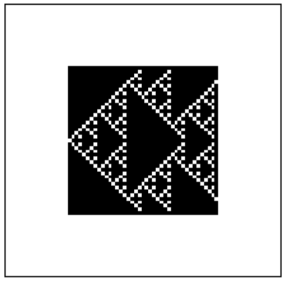
- Von Neumann and Ulam
  - Cellular Spaces
  - Purpose of Possible realization of biological systems
  - Modeling of Biological Reproduction
- Many Names
  - Tesselation automata
  - Homogeneous structures
  - Iterative arrays

Applications of CA

- Biological Systems
  - Growth of organisms
  - Populations of non-mobile organisms (plant) with local ecological interaction
- Parallel Computing
  - Highly parallel multiplier
  - Image processing and visual pattern recognition
  - Possibility of computer implementation at a molecule level (?)

1-d CA example

- Elementary CA:
  - Site values: 1 or 0 (“base 2”)
  - “neighborhood”: the site itself and the sites immediately adjacent to it on the left and right
  - 1-d 3-ca case
- **Modulo 2 rule case**
  - A rule: Sum modulo 2 of its two neighbors



111	110	101	100	011	010	001	000
0	1	0	1	1	0	1	0

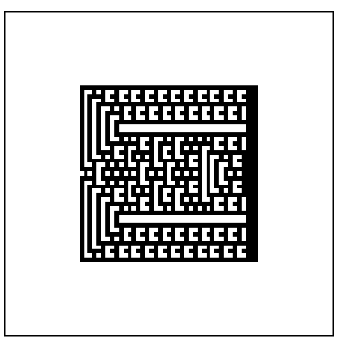
0 1 0 1 1 0 1 1 0 1 0 1 0 1 1 1 0 0 0 1 0
0 0 1 1 0 1 1 0 0 0 0 0 1 0 1 1 0 1 0

General rules for 1-d CA example

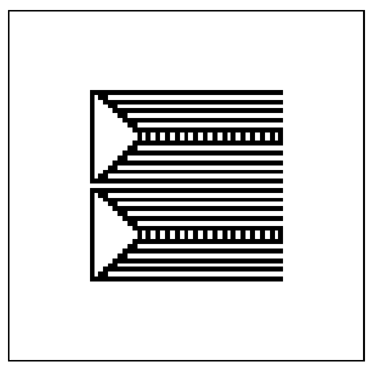
- A rule is described by 8-digit binary numbers

111	110	101	100	011	010	011	000
1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	0
…..	…..	…..	…..	…..	…..	…..	
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0

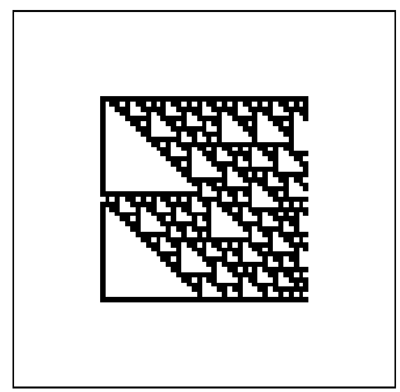
- There are 2^8=256 possible distinct CA rules



y_{FRAME}



y_{Ts}

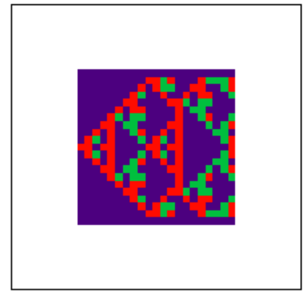


y_{Ts}

1-d CA with 3 site values (0,1,and 2)

- A Simple Rule

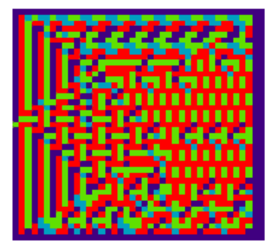
SUM: 6 5 4 3 2 1 0
x_{t+1} : 2 1 0 1 2 1 2 (Example)

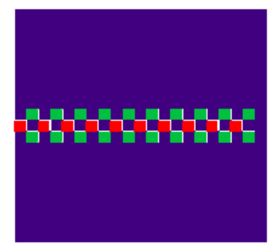


- General Rules

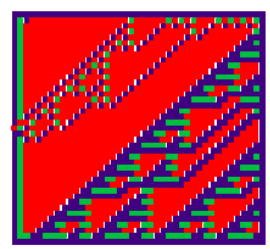
222 221 220 212 211 210 202 201 200 122 121 120 112 111 110 102 101 100 022 021 ...

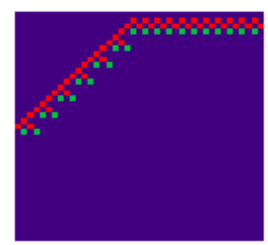
2 2 2 2 ....
....
0 0 0 0





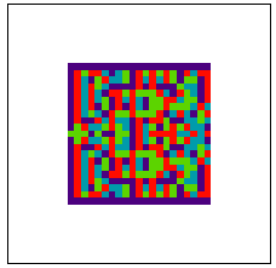
If we ignore the current site's status in the rule formation, it reduces to:
22 21 20 12 11 10 02 01 00 (9 kinds)
2 2 2 2 2 2 2 2 2
0 0 0 0 0 0 0 0 0
Then, there are only 3^9 = 19683 possible rules.





1-d CA with 4 site values (0, 1, 2, and 3)

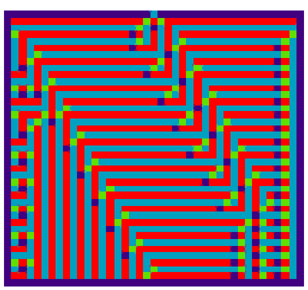
- A simple rule by Sum of the neighboring site values.

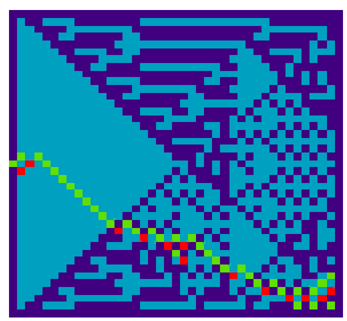


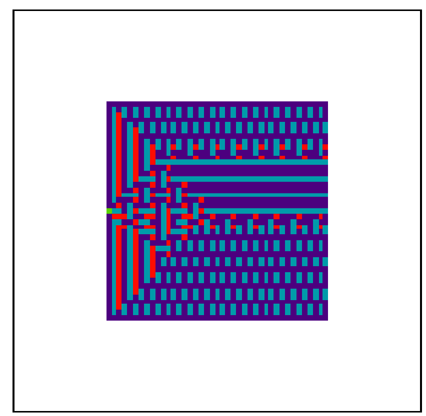
yTs

- General Rule

If we ignore the current site's status in the rule formation, it reduces to:
33 32 31 30 23 22 21 20 13 12 11 10 03 02 01 00 (16 kinds)
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Then, there are only 4^16 is close to 4.3 billion possible rules.



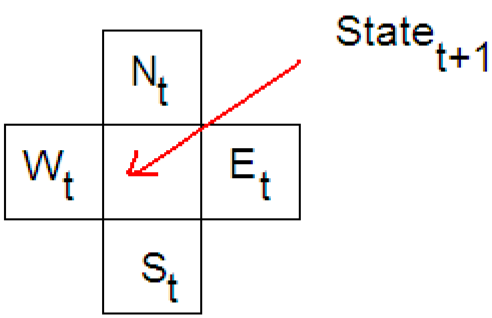




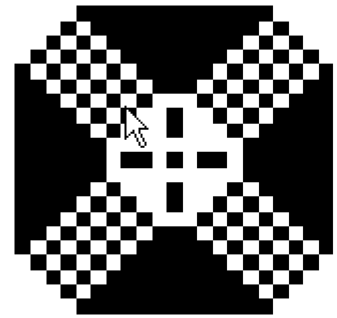
yTs

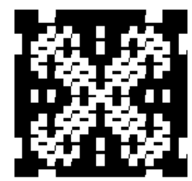
2-d CA with 2 possible values (0,1)

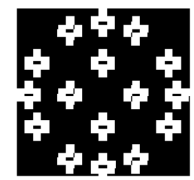
- **Simple rule by Sum:**



for $xx \in 0..N$
  for $yy \in 0..N$
    $SUM \leftarrow West_{xx,yy} + East_{xx,yy} + North_{xx,yy} + South_{xx,yy}$
    $ZZ_{xx,yy} \leftarrow 0$
    $ZZ_{xx,yy} \leftarrow 1 \text{ if } SUM = 0 \vee SUM = 3$
$x_{t+1} \leftarrow ZZ$



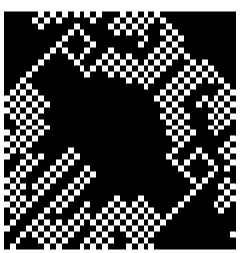


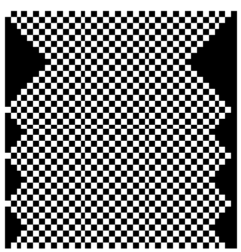


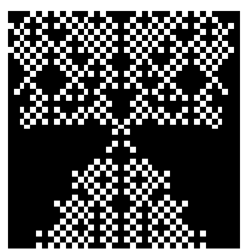
- **General Rules**

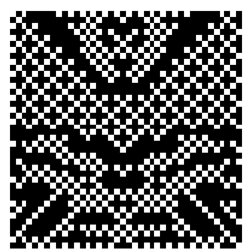
Therefore, there are: 2^16 rules (=65536 rules)

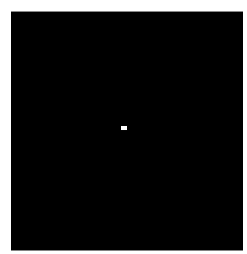
1111	1110	1101	1100	1011	1010	1001	1000	0111	0110	0101	0100	0011	0010	0001	0000
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0





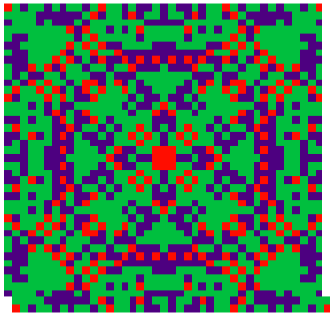


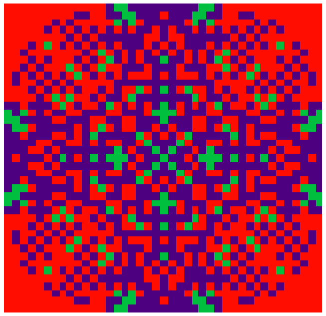




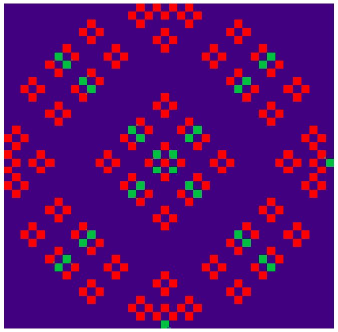
2-d CA with 3 values (0,1,2)

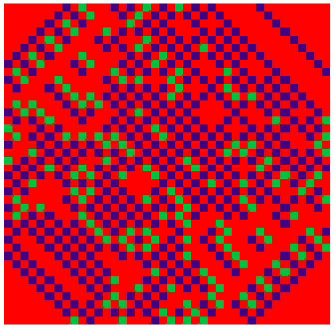
- Rules be the Sum

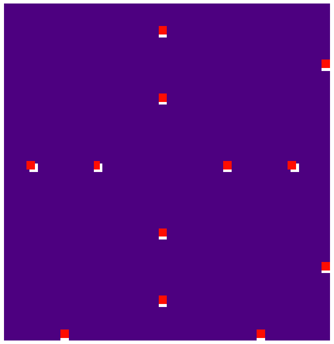


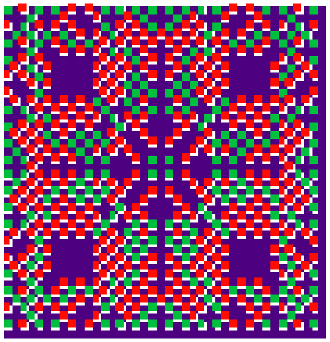


- General Rules



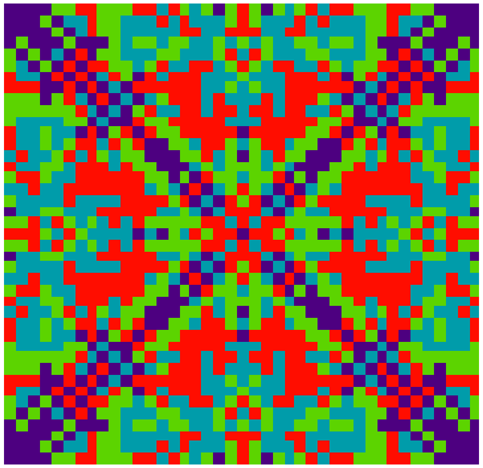


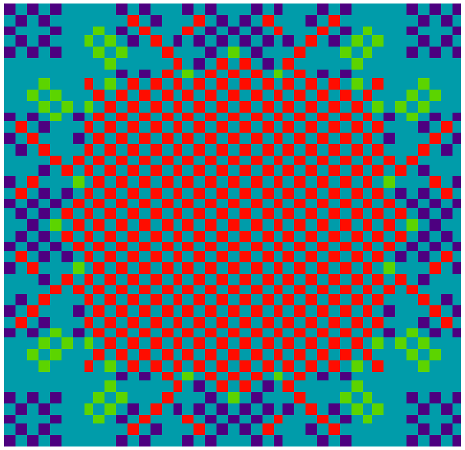




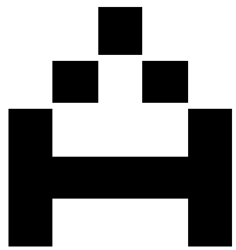
2-d CA with 4 values (0,1,2,and 3)

- Rules by the Sums





Reversible CA - 1



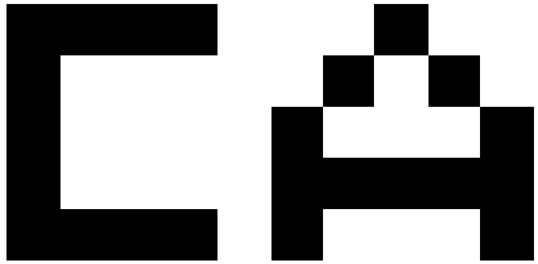
Final configuration

Final configuration

Final configuration

Final configuration

Reversible CA – 2



Time Step

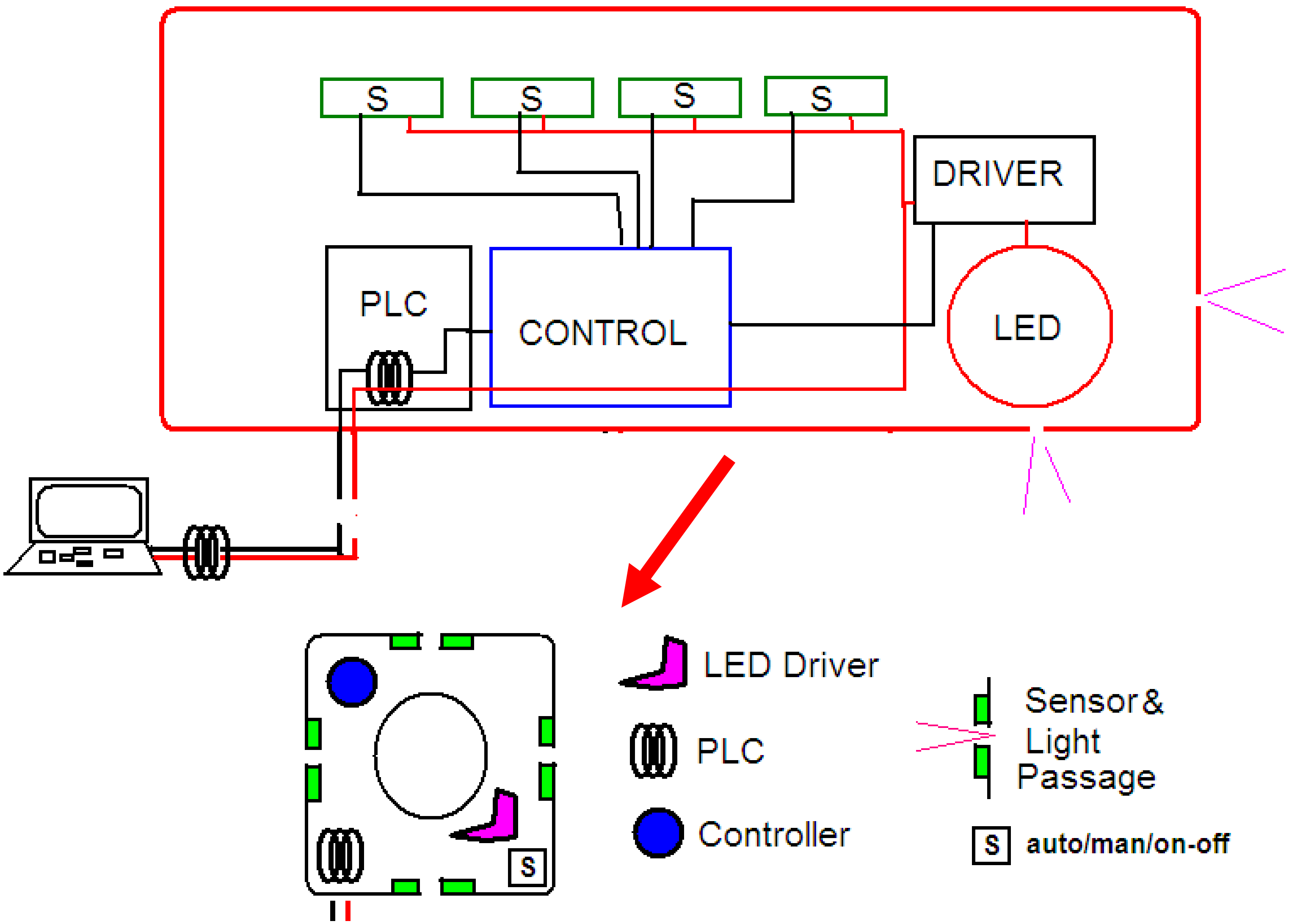
Time Step

CA Application in LED Array Control

- **PC based LED Array Controller**
  - Equipped with Power Line Communication or Visible Light Communication
- **Hardware (in LED fixture)**
  - Controller
  - Communication
    - Visible Light Communication
    - Power Line Communication
  - Sensor
    - Photo Detector
    - Color Sensor
  - LED controller
    - Driver
    - Timing Circuit

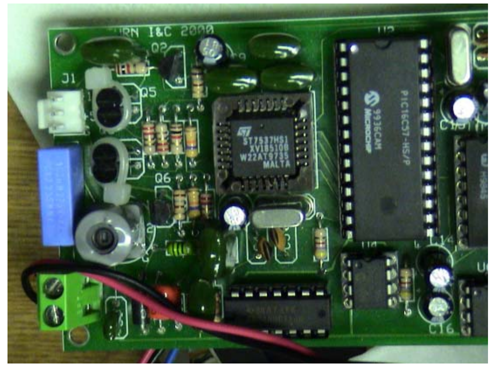
- **Software1 (LED Array Controller)**
  - Rule Generation and Selection
  - Rule Broadcasting through the Communication
- **Software 2 (for the controller in the LED Fixture)**
  - Rule Reception
  - Neighbor Detection and Rule Execution
  - Timing Generation
  - Number of Steps

LED Array Control Schematics



Rule Broadcasting via PLC

- OLD



- NEV

PRODUCTS

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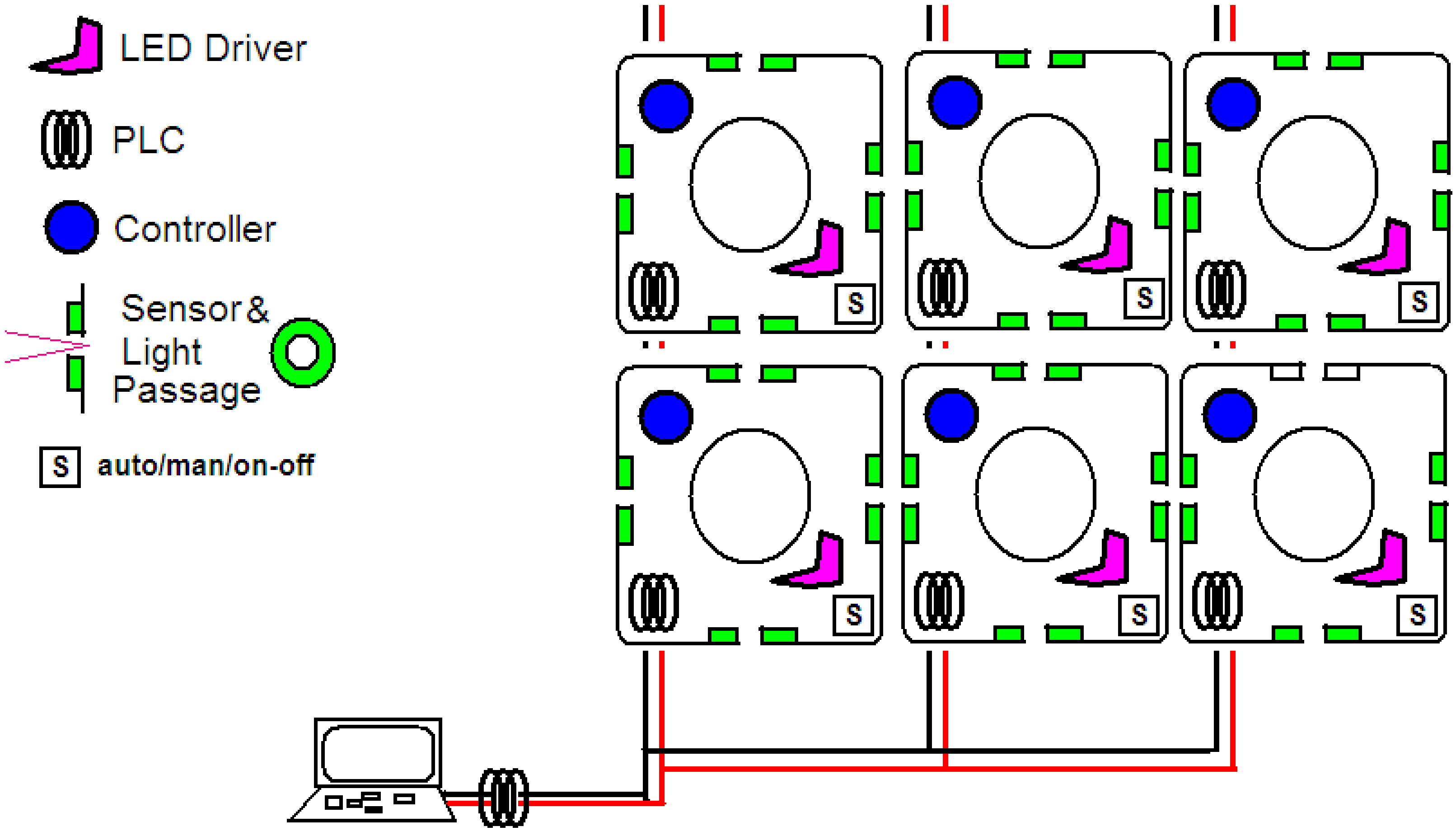
Cypress introduces PLC-enabled PSoC IC with integrated LED drivers

Date Announced: 22 Mar 2010

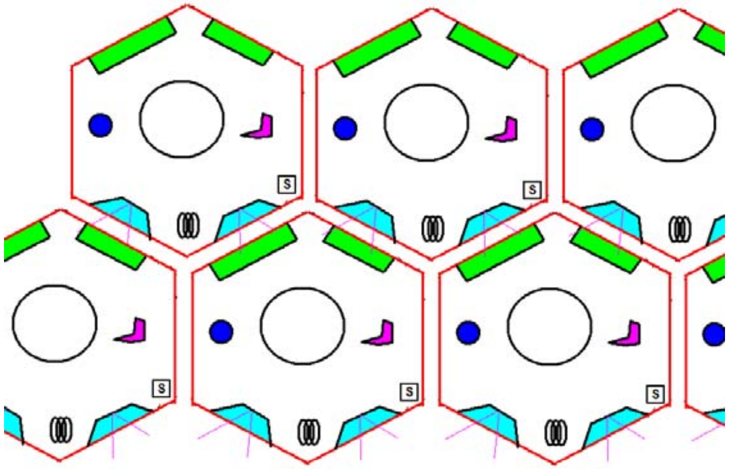
Cypress Semiconductor Corp. (NASDAQ: CY) today introduced the world's first truly programmable solution for data communication over existing power lines. Leveraging the programmable analog and digital resources of Cypress's PSoC(r) programmable system-on-a-chip architecture, the new Cypress Powerline Communication (PLC) solution integrates multiple functions beyond communication, such as power measurement, system management and LCD drive. In addition to its flexibility and integration, the new solution offers industry-leading reliability with greater than 97% packet success rates without retries and 100% success rates with retries built into the solution's coding. The solution offers the flexibility to communicate over high-voltage and low-voltage power lines for lighting and industrial control, home automation, automatic meter reading and smart energy management applications.

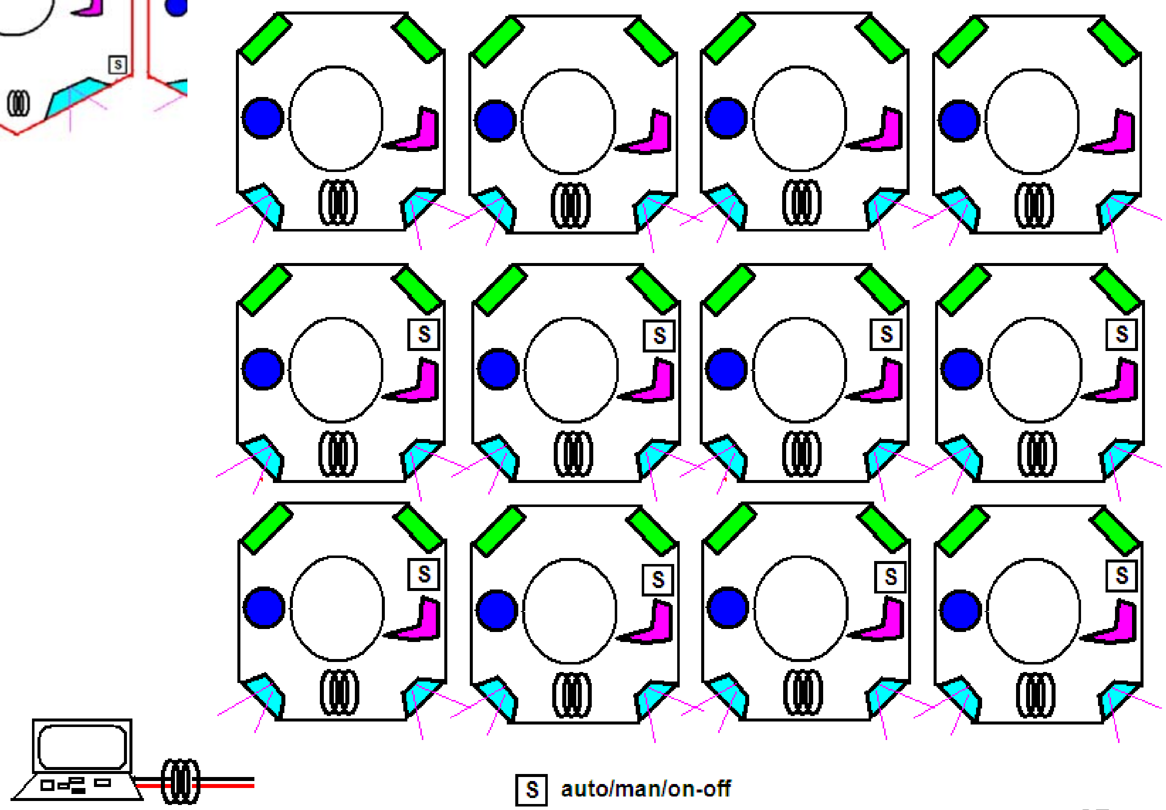
2-d CA case



LED Driver
PLC
Controller
Sensor & Light Passage
S auto/man/on-off
S

1-d CA Case





CA-based LED Array Control – Advantaged and Weaknesses

- Advantages
  - Plug-and-Play style LED array control
  - Less Wiring
  - Less Control hardware (overall) and Software

- Weaknesses
  - Only ruled patterns can be generated
  - More hardware/software burden in LED fixture

Conclusions

- CA's Promises and Problems as an alternative LED array control approach
  - Saving in wire
  - Saving in control devices
- Rich patterns but not tailored patterns
  - Artistic
  - Aesthetic
- Needs a demonstration project