Security Control Framework for Nanoscale Networks

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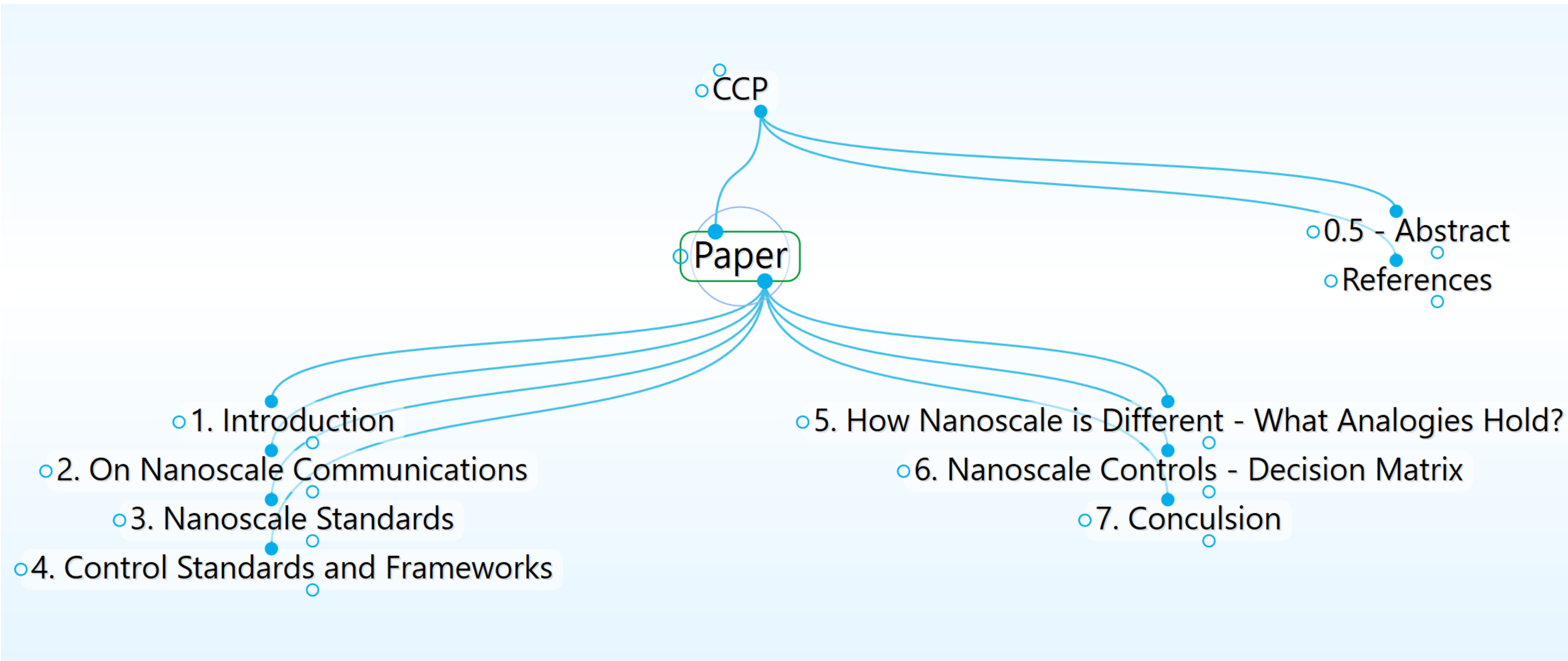
Structure of Paper



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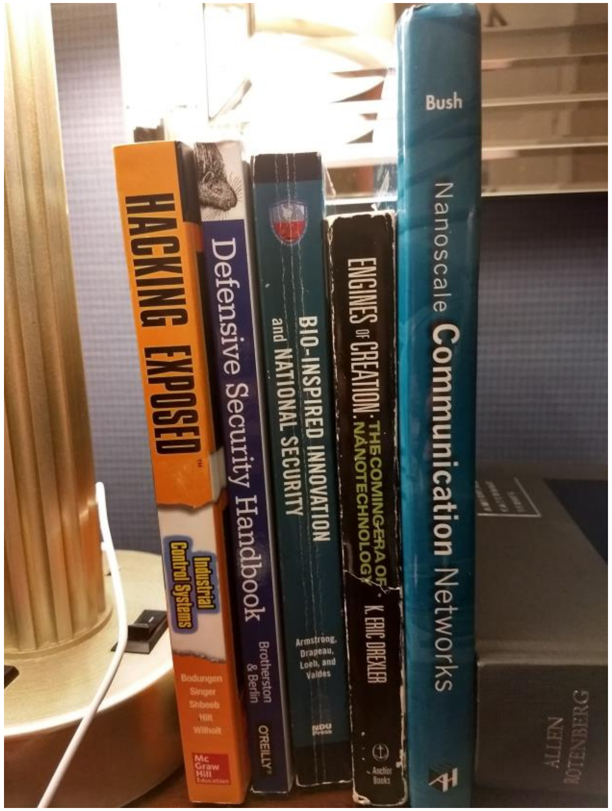
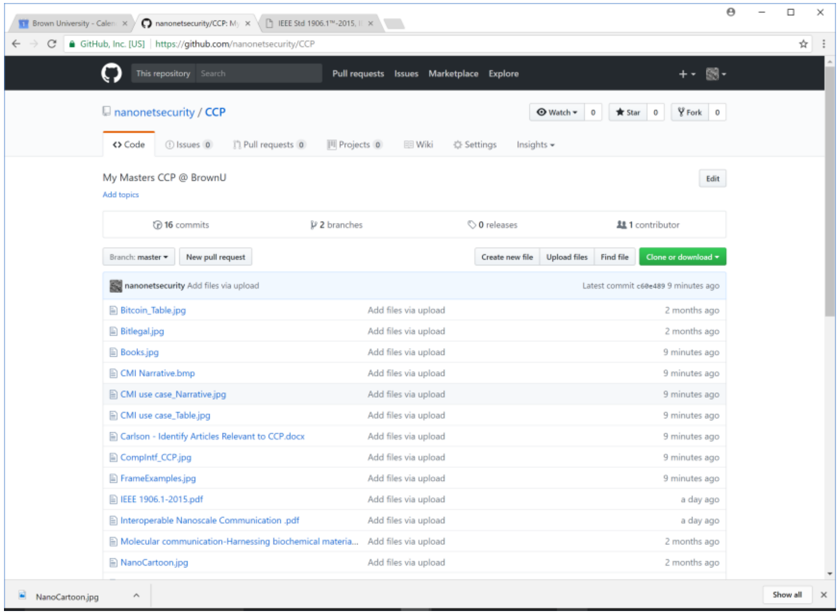
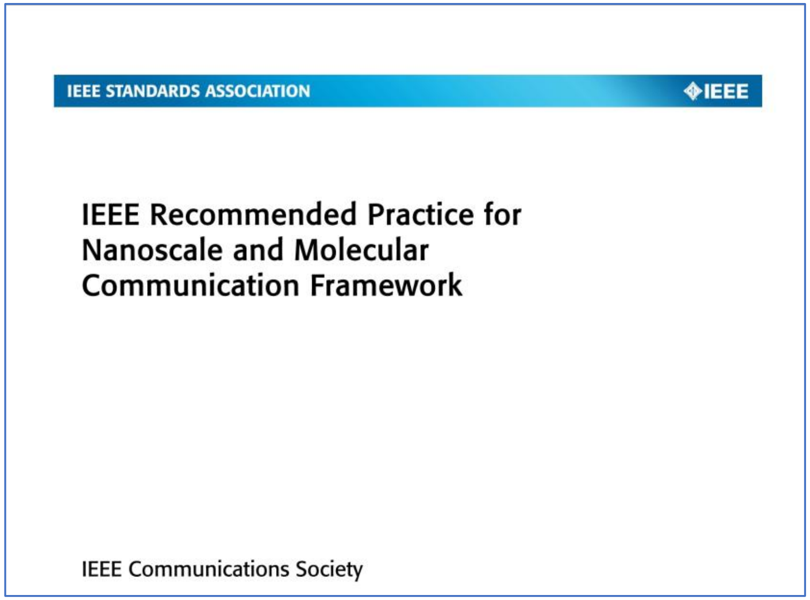
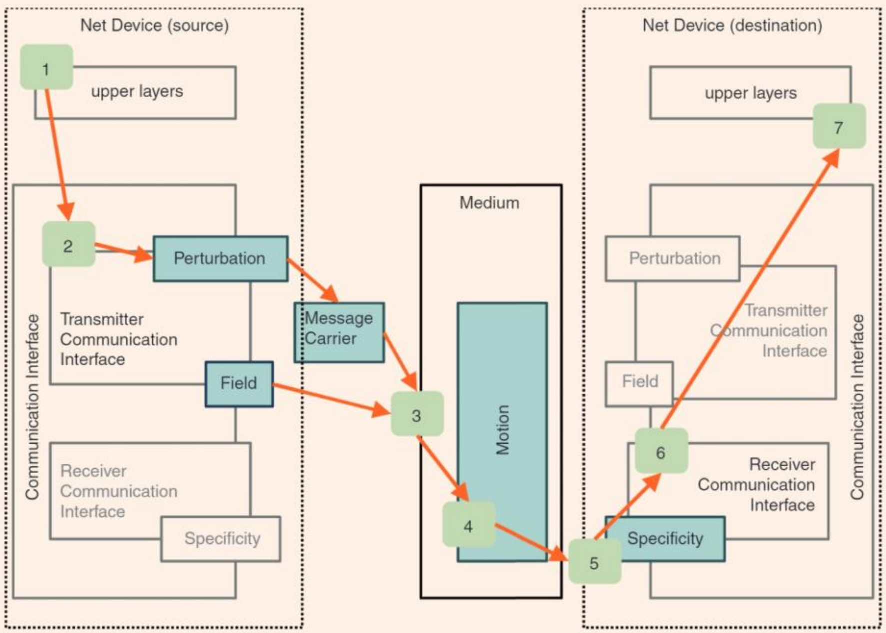






https://github.com/nanonetsecurity/CCP

What is a Nanoscale Network?



Adapted from IEEE P1906.1/Draft 1.0 Recommended Practice for Nanoscale and Molecular Communication Framework

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Table 1—Example nanoscale communication network components

Layer name	Explanation	Example (molecular)	Example (nanotube/terahertz)
Specificity	Correctly detect true versus false messages	Shape or affinity of molecule to a particular target, complementary DNA for hybridization, etc.	Antenna aperture, resonant frequency, impedance match
Perturbation	Vary concentration or motion as needed for signal (shockwave)	Dense versus sparse concentrations of molecules, on versus off flow of signal molecules or motors, conformational changes in molecules, etc.	Amplitude, frequency, or phase modulation
Field	Organized flow direction	Flowing liquid, applied EM field, motors attached to microtubules, concentration gradient of chemical molecules, swarm motion, etc.	Omni or directed with multiple CNTs
Motion	Potential communication channel in the wild (semi-random)	Molecules diffusing through liquid, unattached molecular motors, Brownian motion, self-propelled motion, etc.	Wave propagation and phase velocity
Message Carrier	Mass and energy	Molecular chain, etc.	EM wave

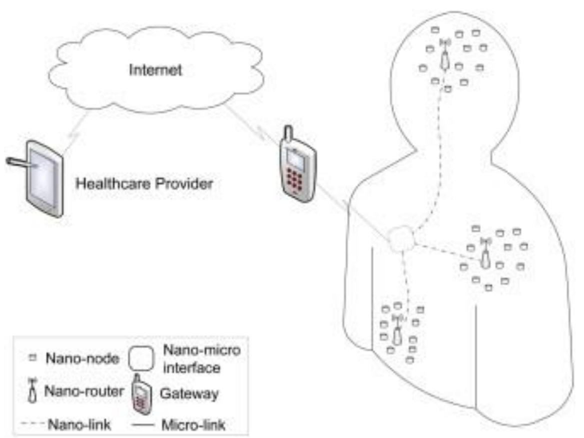
Use Cases (IEEE 1906)

B.4 Wireless nanosensor networks

It is envisioned that the concentration of sodium, glucose, and other ions in a person's body can be monitored by means of nanoscale sensors or nanosensors. A nanosensor network can be formed in which several such sensors are distributed around the body to collect relevant data. Each sensor node is equipped with a CNT-based nanoantenna that acts as the transceiver, which uses a THz frequency band to communicate. The mapping of this EM-based communications to the IEEE 1906 framework is given in Table B.4.

Table B.4—Wireless nanosensor networks use-case mapping to the IEEE 1906.1 framework

IEEE 1906 component	Corresponding components
Transmitter	CNT-based nanoantenna
Receiver	CNT-based nanoantenna
Message	Sodium concentration
Medium	Air
Message carrier	Electromagnetic (EM) wave
Component < 100 nm	Sensor, message carrier (THz frequency wave)
Non-standard physics	Impact of scale on resonance
Motion	Radiation and waveguide
Field	Intensity/directional antenna
Perturbation	RF modulation
Specificity	Receptor sensitivity/antenna aperture



Source: Electromagnetic wireless nanosensor networks
Author F. Akyildiz Josep Miquel Jornet

B.2 Targeted drug delivery with CRLX101

Delivery of drugs directly to malignant tissue while minimizing toxicity has been an important goal in nanotherapeutics. Camptothecin (CPT) exhibits anti-cancer activity against several types of cancer cells including gastric cancer and animal tumors. This is due to the inhibition of DNA topoisomerase I (Topo-1) causing cell death because Topo-1 is essential for basic cellular processes including DNA replication, recombination and transcription. Topo-1 is up-regulated in rapidly dividing tumor cells. CPT was not used clinically because of its poor solubility and high systemic toxicity before CRLX101.

CRLX101 (Weiss, et al. [B12]) is a dynamically tumor-targeted nanopharmaceutical consisting of a cyclodextrin-based polymer (CDP) molecule and CPT, which conjugates with CDP forming 30 nm to 40 nm nanoparticles. This conjugation increases the solubility and also reduces toxicity when the drug is administered systematically.

CRLX101 selectively targets tumor cells because of leaky vasculature (enhanced permeability and retention [EPR] effect). Nanoscale communication is evident here. CRLX101 slowly releases CPT when the linkage is hydrolyzed. The receptors on the gastric cell lines receive CPT, which then starts the antitumor activity. The mapping of this use-case to the IEEE 1906.1 framework is shown in Table B.2. The specificity is considered low since CRLX101 can accumulate at tumor tissues other than the desired one due to the EPR effect.

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Table B.2—Mapping targeted drug delivery use-case to IEEE 1906 framework

IEEE 1906.1 component	Corresponding components
Transmitter	CDP
Receiver	Receptor on gastric cancer cell lines (MCG803)
Message	CPT
Medium	Cell-culture media
Message carrier	CDP
Component < 100 nm	CDP-CPT nanoparticles
Non-standard physics	Brownian motion
Motion	Diffusion based
Field	Gradient based
Perturbation	Loading CRLX101 with CPT
Specificity	Low

Framework Examples

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Table 4—IEEE 1906.1 framework examples

IEEE 1906 component	Example 1: Calcium waves	Example 2: Receptor-ligand	Example 3: Molecular motor	Example 4: Nanotube network	Example 5: Flagellated bacteria	Example 6: THz waves
Message Carrier	Calcium ion concentration	Ligand concentration	Molecular motor and cargo	Charge	Bacterium and cargo	EM wave
Motion	Diffusion	Diffusion	Walking and directed diffusion	Potential difference	Goal-driven (food/light)	Radiating and waveguide
Field	Directed concentration gradient or compartmentalization	Directed concentration gradient or receptor clustering	Microtubule polarity and connectivity	Nanotube orientation	Chemical concentration of food particles, and intensity of light	Intensity/ directional antenna
Perturbation	Transmission rate or concentration change	Transmission rate or concentration change	Change in number and types of molecules inside the cargo	Current (amperage) variation	Change in number and types of molecules inside the bacteria	RF modulation
Specificity	Calcium sensing receptor sensitivity to Ca+	Receptor sensitivity to ligand	Receptor sensitivity to cargo	Receiver sensitivity to charge	Receptor sensitivity to bacterium or cargo	Receptor sensitivity/ antenna aperture

IEEE 1906 to OSI Model

Table 2 —Example OSI to nanoscale communication network mapping

OSI model	IEEE 1906 component mapping			Explanation
Application				No 1906 component
Presentation				No 1906 component
Session				No 1906 component
Transport				No 1906 component
Network		Field		Field may enable Message Carrier transport across multiple nodes
Data Link	Specificity	Motion		Motion, enhanced by Field and Specificity, enable Message Carrier to reach next-hop node
Physical	Message Carrier		Perturbation	Perturbation creates the signal transported by the Message Carrier using Motion

Note: Nothing after Layer 3. This turns almost every control framework in cybersecurity on its head from a technical POV.

Control Frameworks

- Overall (Enterprise/Strategic)
  - ISO/IEC 27001, 27002, 27003, 27004, 27005, 27006…
  - NIST 800-53
  - NIST Cybersecurity Framework
  - Payment Card Industry Data Security Standard (PCI DSS)
  - Health Insurance Portability and Accountability Act
  - Gramm-Leach-Bliley Act
  - Family Educational Rights and Privacy Act
  - Sarbanes-Oxley Act
- Industrial Controls
  - NIST SP 800-82
  - International Society of Automation 62443
  - North American Electric Reliability Corporation Critical Infrastructure Protection (NERC CIP)
  - Department of Homeland Security Chemical Facility Anti Terrorism Standards (CFATS)
  - US Nuclear Regulatory Commission (NRC)
  - Nuclear Energy Institute

Domains within the Controls!

- Access Control, Asset Management (Privacy), Cryptographic Procedures (yes, there is biological cryptography!), Risk Management, Environmental Security, Disaster Recovery, Application Development Security, Governance.
- I will not be able to do all of the controls within the groups, but I think I have space to do two - Access Control and Disaster Recovery are my picks.

End Result

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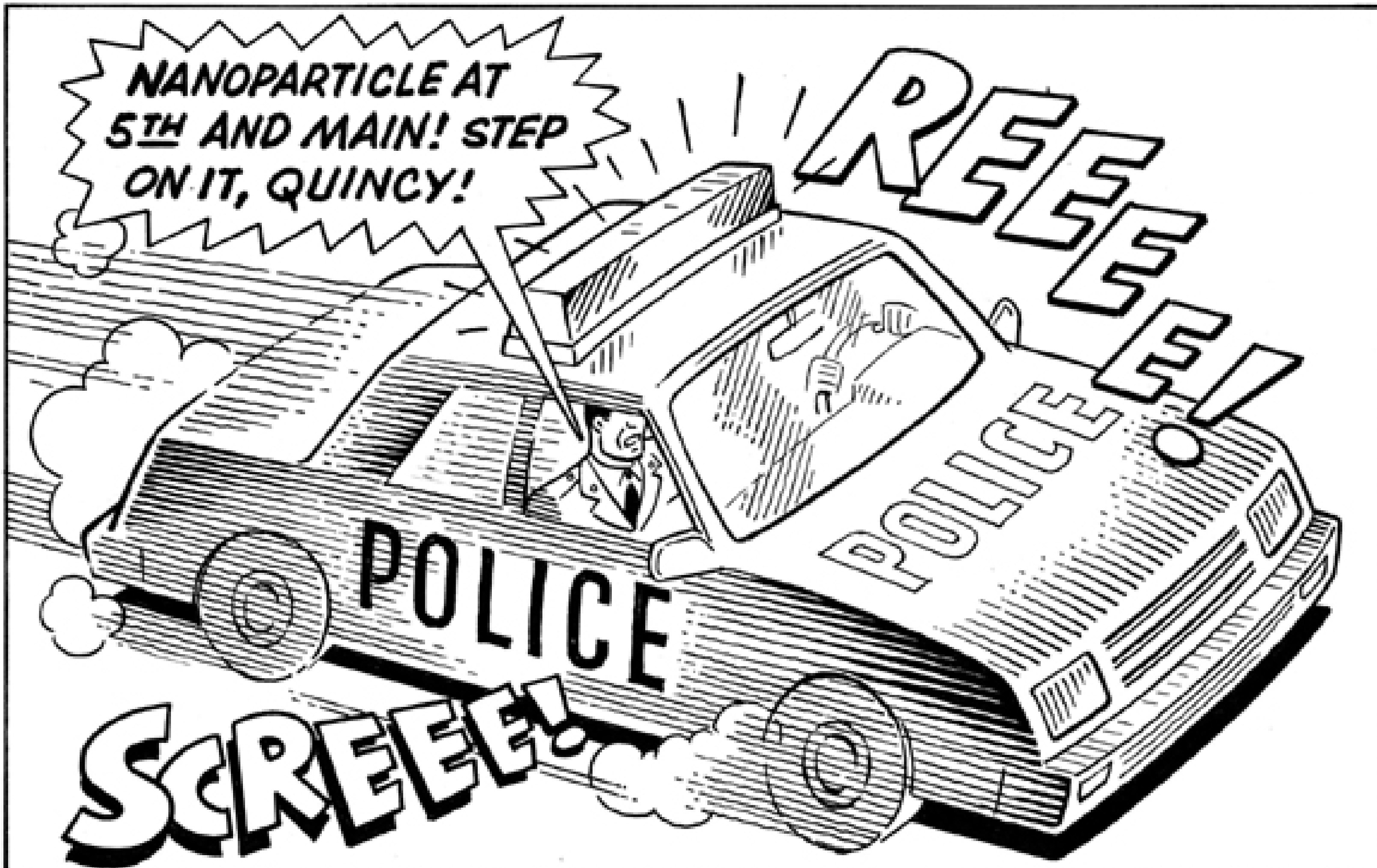
Questions?


NANOPARTICLE AT 5TH AND MAIN! STEP ON IT, QUINCY!
REEEEE!
POLICE
POLICE
SCREEE!